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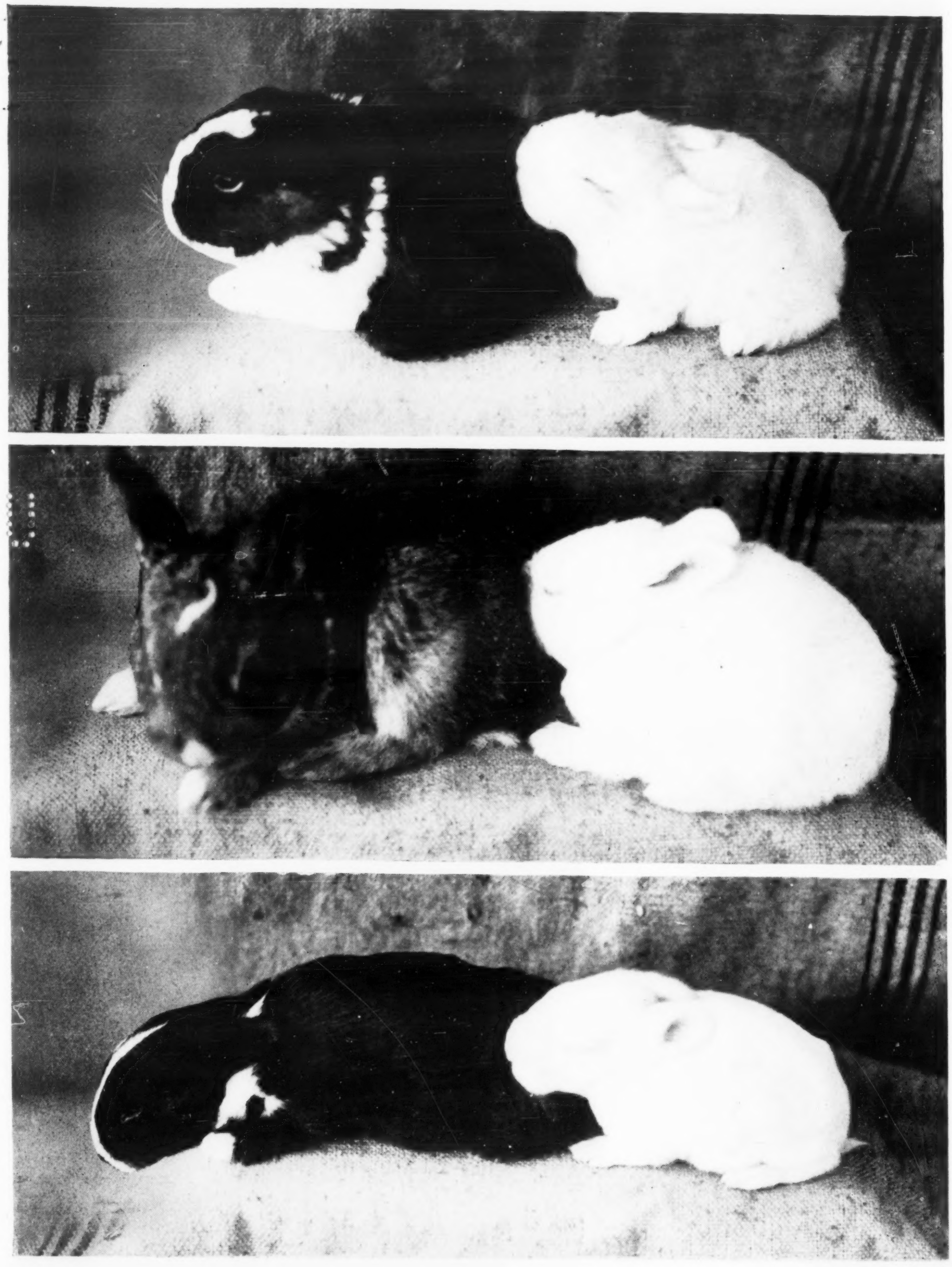

LEAD AS A RACIAL POISON

That lead poisoning can effect the germ-plasm of guinea pigs is indicated by experiments under way at the University of Wisconsin. These photographs of results were supplied by Professor Leon J. Cole, who writes: "Each of the photographs shows two young from the same litter, in all cases the mother being a normal (non-poisoned) albino. In each of the litters the white young is from an albino father which received the lead treatment, while the pigmented offspring is from a normal homozygous pigmented male. While these are, it is true, selected individuals, they represent what tend to be average rather than extreme conditions. The albino male was considerably larger than the pigmented male; nevertheless his young average distinctly smaller in size. Note also the brighter appearance of the pigmented young one." (Frontispiece.)

See Live-Stock Genetics, p. 21.

SEXUALITY IN PLANTS

Observed But Not Understood by Babylonians and Assyrians—Not Proved Experimentally Until Seventeenth Century—Early Observers Hampered by Lack of Proper Methods—Evolution of the Problem Largely Due to a Few Great Men.[1]

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FROM the beginning of man's thoughtful consideration of natural processes, the phenomenon of sexual reproduction, with the associated phenomena of heredity, have persistently engaged his keenest interest. The primary fact of the necessary concurrence of two individuals in the production of offspring was, in the case of animals, recognized from the beginning. The equivalent phenomenon was not established for plants until the end of the seventeenth century. At this time, however, little more was known of the essential features of the sexual process in animals than had been familiar to Assyrians, Egyptians and Greeks twenty centuries before.

Of the additions made since 1700 to our knowledge of sexual reproduction, of its varied types and of the associated phenomena, no mean share has been contributed by botanical investigators. Noteworthy among such contributions are the work of Koelreuter and Mendel in the production and systematic study of plant hybrids, and the early work of Pfeffer on the chemoatactic response of spermatozoids. Of more recent work we may cite that of the plant cytologists on apogamy and apospory, on multinucleate sexual cells or gametes, and on the long-delayed nuclear fusion in the sexual reproduction of the plant rusts. It should then be of interest for us to consider just how and when the more important steps have been taken in building up the vast mass of somewhat incomplete knowledge that we now possess concerning the reproductive process in plants. Because of exigencies of time and patience, I shall confine myself primarily to an attempt to picture the chief steps by which our present knowledge of the essential sexual process, the union of two parental substances, has been attained. Incidentally, we may note the changes in point of view of investigators and in their mode of attack on this problem. I shall attempt to suggest the trend of development more clearly by often grouping the chief phenomena discovered in such a way as to indicate the sequence of discovery, within each group, of the different phases of the sexual process, though the order of discussion may thus not always accord with the sequence of the discovery of individual phenomena in plants as a whole.

WORK OF GREAT MEN.

In following the evolution and change in aspect of our problem we shall often find it best to keep a few relatively great names prominent. This will serve in the first place to make the story more vivid and intelligible. It will at the same time often come nearer the essential truth, for in each great forward step some one worker has usually been the dominating leader.

The first discoveries pointing to the existence of sex in plants were evidently made very early in human history by

[1] Address of the vice-president and chairman of Section G, Botany, American Association for the Advancement of Science, December, 1913. (This address, in its complete form, was published in *Science*, N. S., Vol. XXXIX, pages 299-319, 1914.) The illustrations have general bearing on the subject discussed and were selected as being more readily intelligible than the detailed technical drawings of the early investigators, whose works are referred to.

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THE DATE PALM AMONG THE ASSYRIANS

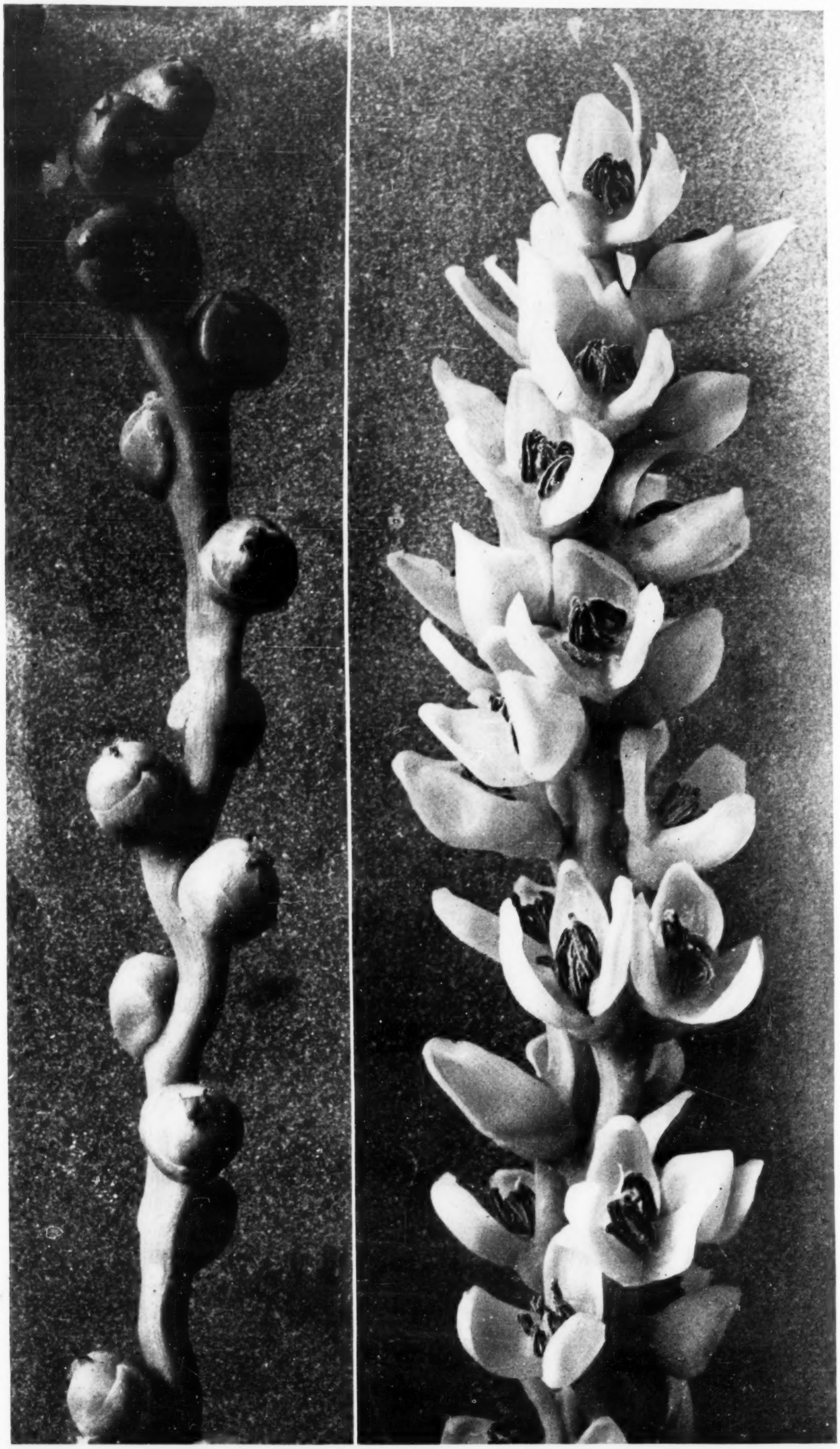
Design from the palace of Sargon at Khorsabad (eighth century B. C.) showing that the male and female flowers of the date palm were clearly distinguished at that time. The worshiper in the middle is carrying a sprig of male or staminate flowers while the one at the right bears female or pistillate blossoms. The drawings should be compared with the photographs of actual flowers in fig. 2. The winged deity at the left, who is usually identified as the Palm God, holds in his hand a cone which is thought to typify the spathe of the male palm, and thus the principle of fertility in general. (Fig. 1.)

peoples cultivating unisexual plants for food. The existence of fertile and sterile trees of the date palm, *e. g.*, was known to the peoples of Egypt and Mesopotamia from the earliest times. Records of the cultivation of these trees and of artificial pollination have come down to us on bas-reliefs from before 700 B.C. found in the palace of Sargon at Khorsabad (Haupt and Toy, 1899).[2] The Assyrians, it is said, commonly referred to the two date trees as male and female (Rawlinson, 1866). The Greeks, in spite of their peculiarly keen interest in natural phenomena, failed to offer any definite interpretation of this well-known fact concerning the date palm. Aristotle and Theophrastus report the fact, gained apparently from the agriculturalists and herb-gatherers, that some trees of the date, fig and terebinth bear no fruit themselves, but in some way aid the fertile tree in perfecting its fruit. But without recording a single crucial experiment on the matter, Theophrastus concludes that this can not be a real sexuality, since this phenomenon is found in so few plants.

EARLY GUESSES.

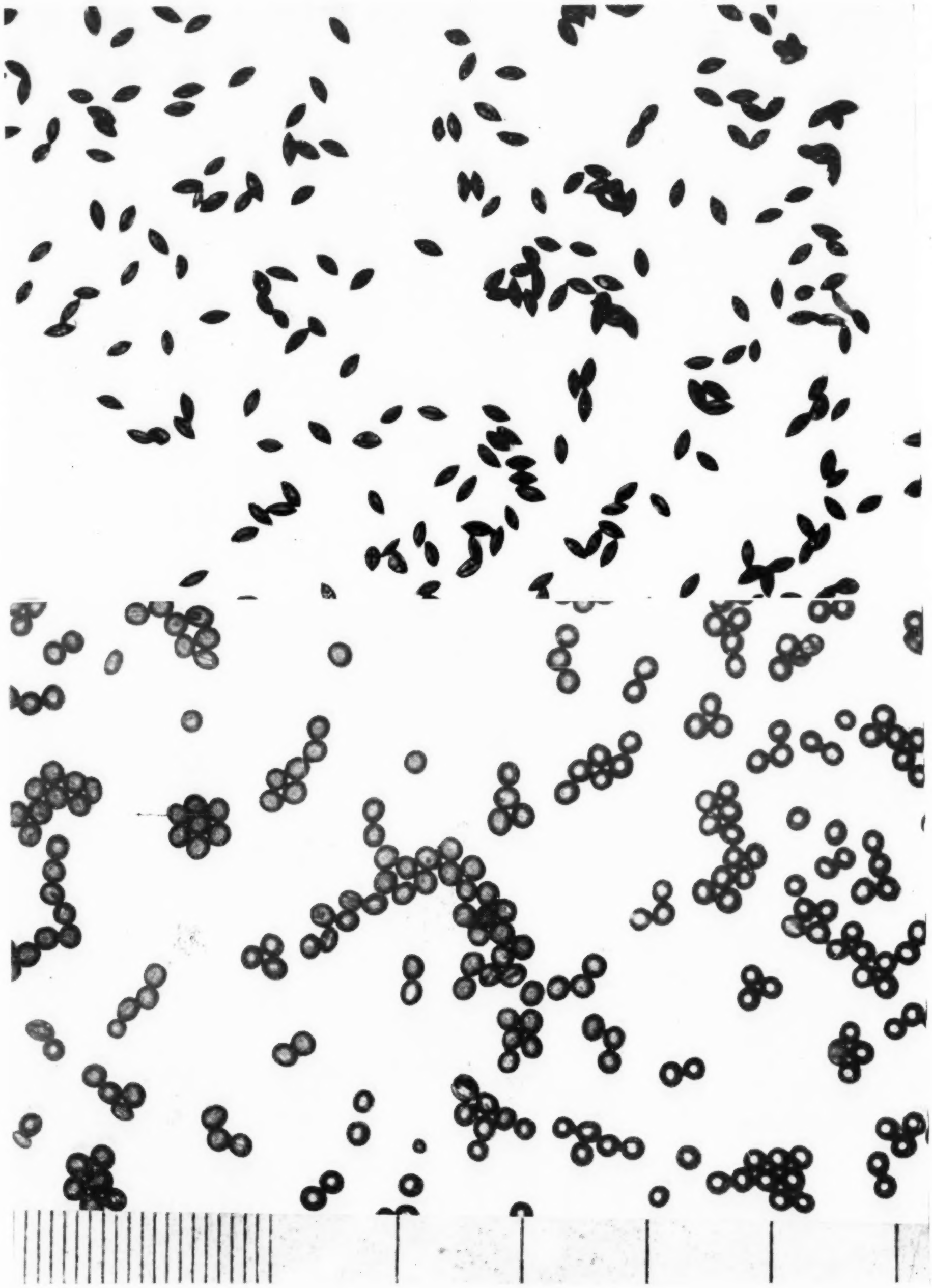
In this uncertain state the knowledge of sexuality in plants was destined to rest for 20 centuries, waiting for the experimental genius of Camerarius to give a conclusive answer to the question raised by the Assyrian and Greek gardeners and answered wrongly by Theophrastus. The English physician Grew (1676) did, it is true, accept and expand the suggestion of Sir Thomas

[2] The dates in parentheses throughout this paper indicate the time each discovery was published and also refer directly to the papers listed in the bibliography appended to this paper as published in *Science*.



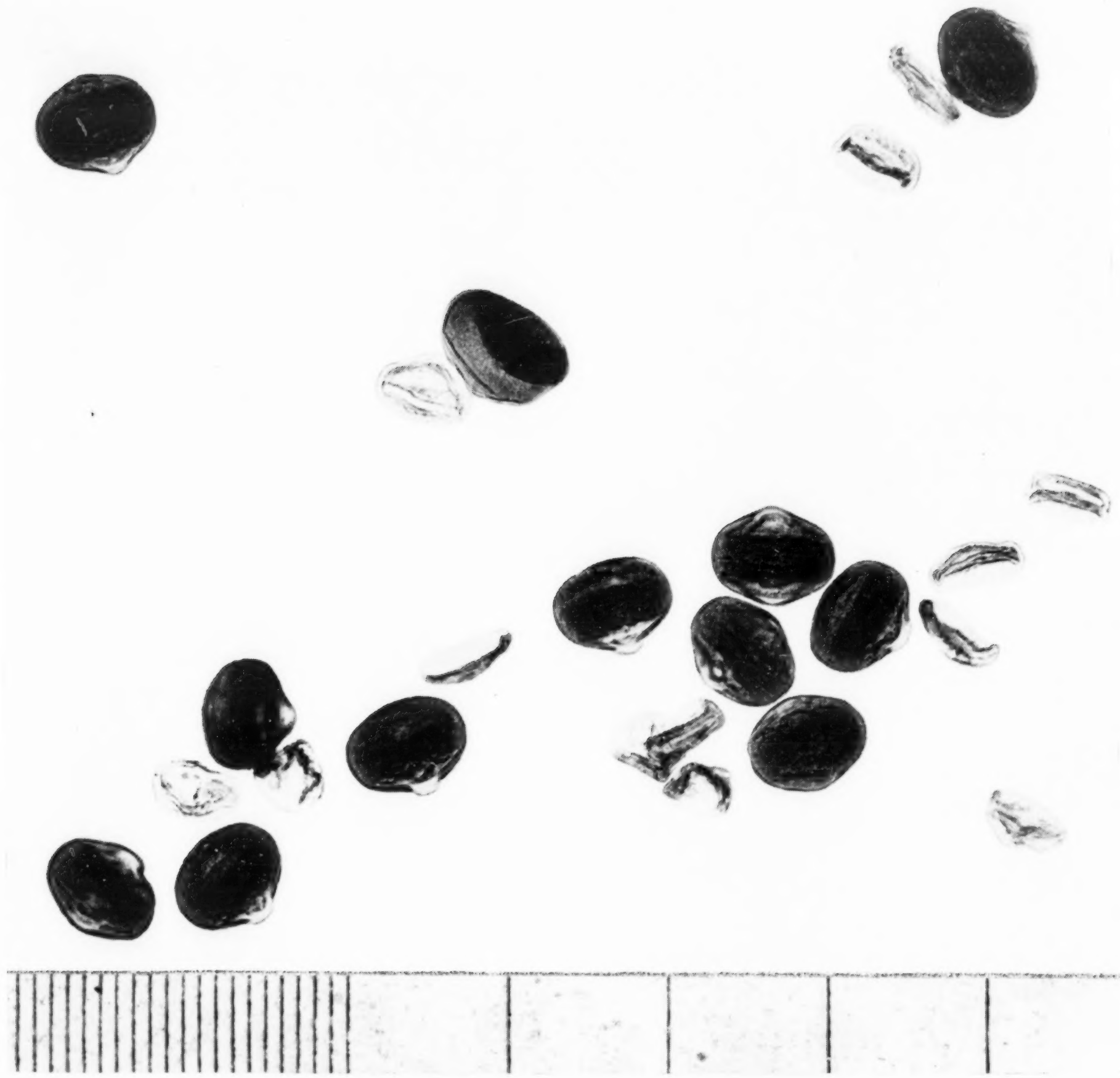
FLOWERS OF THE DATE PALM

On the left is a fragment of the female inflorescence, the short stigma being surmounted by a round ovary without any showy petals. On the right is a sprig of the more conspicuous male or pollen-bearing flower. It is branches of the male inflorescence like this that the date planter ties in the center of each female inflorescence, in order to ensure his crop of dates, which would be worthless unless pollinated. Photograph (much enlarged) from W. T. Swingle, Bulletin no. 53, U. S. D. A. Bureau of Plant Industry. (Fig. 2.)



EFFECT OF MOISTURE ON POLLEN GRAINS

Pollen of *Phoenix canariensis*, a species very closely related to the date palm, photographed at Gainesville, Florida, by John Belling, in October, 1914. The upper photograph shows the dry pollen as it leaves the anthers of the male flower. The microscope slide was then breathed on and another exposure made without shifting any part of the apparatus, the result being shown in the lower photograph. Scale at the bottom is in tenths and hundredths of a millimeter. (Fig. 3.)



FERTILE AND STERILE POLLEN GRAINS

Pollen of the first generation hybrid of the Florida Velvet bean (*Stizolobium deeringiunum*) and the China bean (*S. niveum* var.). In this as in many other crosses of distinct species of plants, half the pollen is sterile and half the ovules aborted. Scale in tenths and hundredths of millimeters. Photograph by John Belling, Gainesville, Fla. (Fig. 4.)

Millington that the stamens serve as the male organs of the plant. Thus Grew concludes (p. 173) that when the anther opens the "globulets in the thecae act as vegetable sperm which falls upon the seed-case or womb and touches it with prolific virtue." But this guess, though it proved correct in the main point, was still a guess, and not supported by any critical evidence so far as recorded by Grew. The only adequate evidence that could be obtained on this question, while microscopes and technique were still so imperfect, was experimental evidence. This kind of proof was first given, some 20 years after Grew's work, by Rudolph Jakob Camerarius, of Tübingen. Camerarius fully appreciated the presence of a real problem here. He also had the genius to see that the philosophical attempts of many of his immediate predecessors, to discover its solution entirely in their own inner consciousnesses, were futile. With the insight of a modern experimenter Camerarius put the question to the plants themselves. The results of his experiments, as reported in the

famous letter of 1694 to Professor Valentin, of Giessen, were clear and conclusive. After noting that aborted seeds were produced by isolated—and therefore unpollinated—female plants of *Mercurialis*, and of the mulberry; by castrated plants of the castor bean; and by plants of Indian corn from which he had removed the stigmas, Camerarius gives his interpretation of these phenomena. He says (Ostwald "Klassiker," p. 25):

"In the vegetable kingdom there is accomplished no reproduction by seeds, that most perfect gift of nature, and the usual means of perpetuating the species, unless the previously appearing apices of the flower have already prepared the plant therefor. It appears reasonable to attribute to these anthers a nobler name and the office of male sexual organs."

In the seventy years after Camerarius had proved in this way the existence of two sexes, and the fertilizing function of the pollen in plants, little advance was made. Bradley, of London, Gleditsch, of Berlin, and Governor Logan, of Pennsylvania, confirmed parts of Camerarius's work, and the great Linnæus accepted the conception of the stamens and pistils as sexual organs as clearly proven, *not*, be it noted, *by the results of Camerarius's experiments* but by "*the nature of plants*."

KOELREUTER'S HYBRIDS.

In 1761 J. G. Koelreuter, of Carlsruhe, published an account of the first systematic attempt that had been made, with either plants or animals, to produce and carefully study artificial hybrids. In his work with hybrid tobaccos, he demonstrated that characters from both parents are often associated in a single offspring. He thus not only completed Camerarius's work, but also, by showing that the male parent participates in the makeup of the offspring, he helped materially to break down the "emboîtement theory" of Christian Wolff, which assumed that the embryo came entirely from the egg, and that its characters could not be influenced by the male parent. It is true that Koelreuter was mistaken in believing that fertilization is accomplished by the mingling of the oil on the pollen grain with the secretion of the stigma to form a mixed fluid, which he supposed then penetrated to the ovule. Nevertheless, his conception of the mingling of two substances was a move with the proper trend.

Koelreuter also demonstrated that in nature the pollen necessary to fertilization is often brought to the stigma by insects. He thus opened up a field of research which was cultivated with such splendid effect by Konrad Sprengel thirty years later, and by Darwin, Müller and others a century afterward.

In spite of the absolutely conclusive work of Camerarius, Koelreuter and Sprengel on the sexuality of plants, their conclusions were often rejected during the first half of the nineteenth century. Certain devotees of the nature philosophy, for example, occupied themselves either in proving over again, after Cesalpino, that plants can not be sexual, *because of their nature*, or in trying, by ill-conceived, and carelessly performed "experiments," to prove the conclusions of Camerarius and Koelreuter erroneous. These objectors were finally silenced, however, when Gaertner, in 1849, published the results of such a large number of well-checked experiments, entirely confirming the works of Camerarius, Koelreuter and Sprengel, that no thinking botanist has since doubted the occurrence in flowering plants of a sexuality essentially identical with that found in animals.

DISCOVERY OF THE POLLEN TUBE

During the opening years of the nineteenth century a number of botanists, who believed in the sexuality of plants, tried to discover by the aid of the microscope just how fertilization is effected. Most botanists of the day believed the pollen grain burst on the stigma, and that its granular contents found a way through the style to the ovary. An entirely new aspect of the problem of fertilization was opened up, however, when in 1823 Amici, of Modena, saw on the stigma of *Portulacca* young pollen tubes arising from the pollen grains. Seven years later he

followed these tubes through the style to the micropyle of the ovule. At about this time also, Jakob Matthias Schleiden (1838) took up the study of this same problem. He was a man of vigorous intellect and great versatility, who sometimes misinterpreted what he saw, but who proved a most stimulating opponent to a number of other workers who did observe accurately. After denying Robert Brown's assertion that the pollen tubes of the orchids arise in the ovary, Schleiden proceeded to describe and figure the pollen tube as penetrating not merely the style and then the micropyle, but even far into the embryo sac itself.

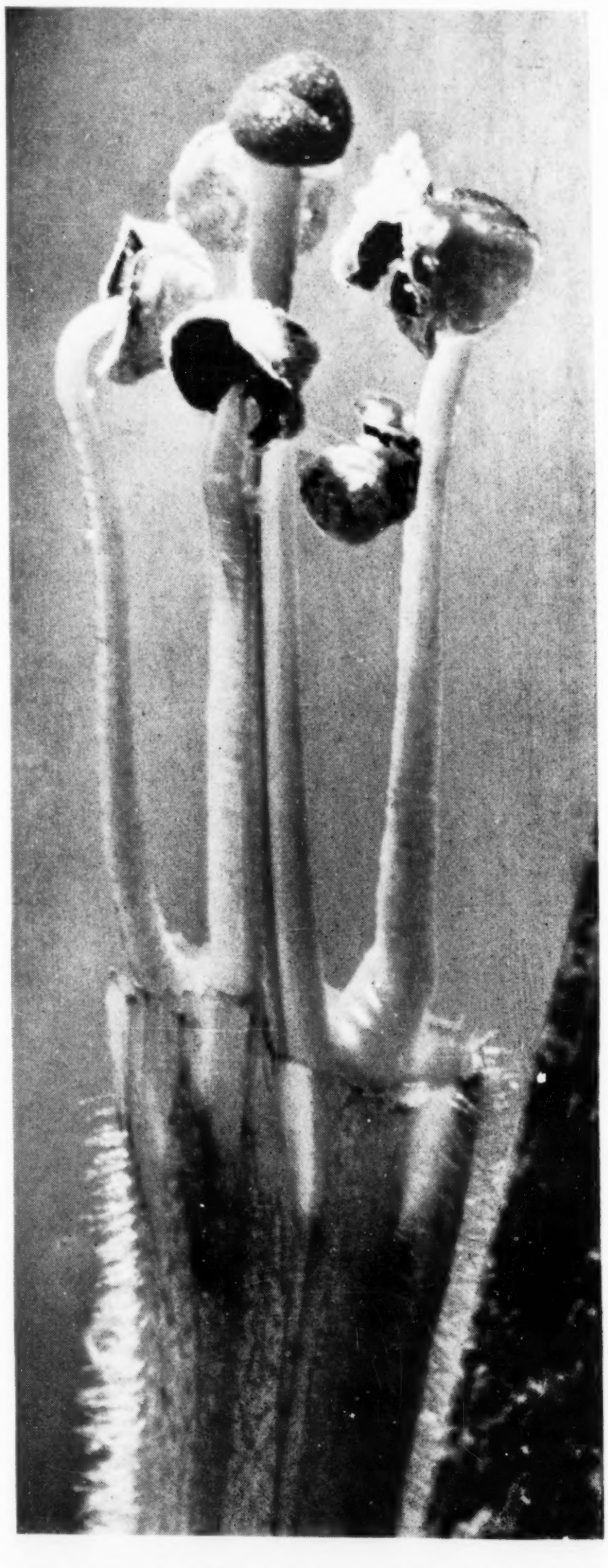
Here, as he says in his Grundzüge (II., p. 373):

"The end of the pollen tube soon swells, either in such a way that the vesicle arising in it fills the whole cavity of the portion of the tube within the embryo sac, or there is left, between the apex of the embryo sac and the embryonal vesicle of the tube, a long or a short cylindrical portion of the latter, the suspensor."

He thus regarded the embryo sac as a sort of hatching place for the embryo, which he thought formed from the end of the pollen tube. This idea of the origin of the embryo really denied the occurrence of any actual sexual process, and made the pollen the mother of the embryo.

ORIGIN OF EMBRYO.

In 1846, however, the error of this conception was clearly demonstrated by Amici, who showed that the embryo of the orchids arises from an egg which is already present in the embryo sac when the pollen tube reaches it. It is this pre-existing egg, according to Amici, that is stimulated to form the embryo by the presence near it of the pollen tube. This view was confidently supported by Mohl (1847) and Hofmeister (1847) in the following year, and the controversy with Schleiden became even more spirited. As Mohl afterward wrote (1863), men were "led astray by their previous conceptions to believe they saw what they could not have seen." The dispute even approached the acrimonious, as when Schleiden (1843) says of one worker's figures,



STAMENS AND PISTIL OF TOBACCO FLOWER

In the center rises the tall stigma with its glossy, knob-like end, the pistil. About it stand five stamens, the anthers of which have already burst open and released the light yellow grains of pollen, which show in the photograph as a brilliant white. Photograph highly enlarged. (Fig. 5.)

MALE FLOWER OF MAIZE

The corn tassel is made up of many slender branches of small flowers, each with a pair of light yellow stamens hung on very slender filaments. From these stamens, half a dozen of which are seen extruded in the photograph, the pollen is dusted by the wind on the corn silk protruding from the husk at some point on the stalk below. This silk consists of long, slender stigmas (female); a pollen grain falls on the end of each one of these and must grow down the whole length of the silk to reach its own particular ovule on the ear, which it fertilizes to produce a grain of corn. Photograph highly enlarged. (Fig. 6.)

"Solche Präparate sind ohne Zweifel aus den Kopf gezeichnet."

Hofmeister, from the beginning of his study of fertilization in seed plants, had sought in the pollen tube for some equivalent of the spermatozoids, those motile male cells of the mosses and ferns that had first been understood by Unger in 1837. He was unable, however, to do more than point out the mistake of earlier observers in regarding the starch grains of the pollen tube as spermatozoids, and to suggest the likelihood that these motile cells might be discovered in the gymnosperms, a prediction the fulfilment of which was realized by Ikeno and Webber 50 years later. In his study of pollen tubes Hofmeister demonstrated to his own satisfaction that the tube does not open in accomplishing fertilization. His view, which was the one current till 1884, was that the egg is stimulated to develop into the embryo by some substance that diffuses through the *imperforate* wall of the pollen tube.

DISCOVERY OF PROTOPLASMIC FUSION.

We come now to consider a series of discoveries of supreme importance in the investigating of the essential sexual process in plants. This is the period in which the problem that had baffled naturalists for twenty centuries was at last solved, at least in one most essential feature, by the demonstration of the occurrence at fertilization of a mingling of paternal and maternal substances.

It will not be without interest at this point to note the intellectual stimuli which led an unusual number of workers to investigate this phase of our problem.

In the first place, there were on record, and under discussion, at the middle of last century, the many puzzling observations of the "Spiralfaden," or animalculæ, as they were thought to be, that had been found arising from a number of plants. These motile, spiral filaments had been seen in a liverwort (*Fossombromia*) by Schmiedel (1747), in *Sphagnum* by Esenbeck (1822), in *Chara* by Bischoff (1828), and finally, on the fern prothallus by Naegeli (1844). Unger (1834-37) studied these bodies in

the mosses (*Sphagnum* and *Marchantia*) and declared his belief that they are not infusoria, but are the male fertilizing cells. At this time also the zoologists of the day were making the first detailed studies of the spermatozoa of animals. Barry (1844) had seen a spermatozoön within the egg of the rabbit; Leuckart (1849) saw them enter the frog's egg, and then, in 1851, Bischoff and Allen Thompson proved that fertilization is accomplished by the actual entrance of the spermatozoön into the egg. A no less important influence, in stimulating the botanical workers on the problem of fertilization, was the magnificent work of Hofmeister, on the reproductive structures of the mosses, ferns and conifers. By these splendid researches he had indicated to men of less insight, and less comprehensive imagination, just the points in the life cycles of plants where the critical phases of the reproductive process are to be sought.

The first step toward the demonstration of a union of two masses of living substance at fertilization resulted from the study of a group of plants in which sexuality had not hitherto been proven or even generally admitted—namely, the algæ. It had, however, long before been suggested in the case of *Spirogyra* by Hedwig (1798) and Vaucher (1803).

STUDY OF ALGÆ.

The algæ were in fact especially advantageous for the study of fertilization, since the development and behavior of the reproductive organs and cells could, without elaborate preparation, be readily seen under the microscope, and often followed through in living material. Thus Thuret, in 1853, for the first time saw the active sperms attached to the egg of *Fucus*, and in 1854 proved experimentally that only eggs to which spermatozoids have had access will germinate. He thus demonstrated in this alga the correctness of Unger's unsubstantiated surmise (1837) that the spermatozoids are the male fertilizing cells. In *Œdogonium*, Pringsheim, in 1856 (p. 9), watched the spermatozoid push into the receptive tip of the living egg and saw the characteristic oöspore wall formed in consequence. This, except for the less satisfactory observations made on *Vaucheria* by the same worker a year previous, is the first case recorded of the observation of the actual union of male and female cells in any plant. Such a union of the protoplasmic masses of the two sexual cells was soon shown to be a characteristic feature of fertilization in a number of algæ. Thus de Bary saw it in *Spirogyra* (1858), and Pringsheim (1869) repeatedly observed the gradual fusion of the motile gametes of *Pandorina*. It was nearly 30 years later, however, that this phase of fertilization was first seen in seed-plants by Goroschankin and Strasburger.

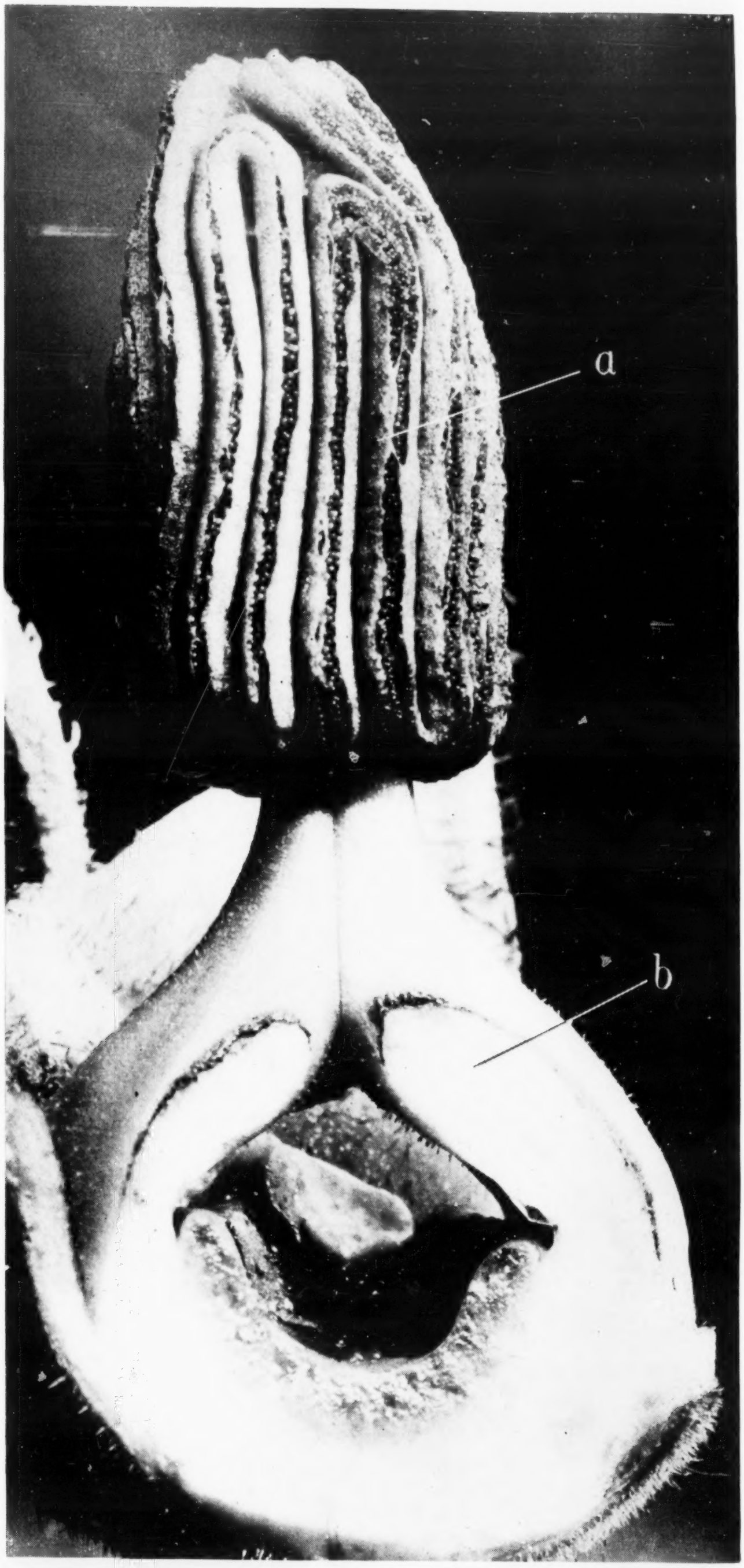
LACK OF PROPER METHODS.

The workers on this problem were on the lookout for further details of the process of fusion, and even knew rather definitely what they were looking for, but failed to discover it from lack of proper methods of preparation of material. Thus, *e. g.*, Strasburger, in 1877, carefully studied the process of conjugation in *Spirogyra* and found that "Hautschicht fuses with Hautschicht, Kernplasma with Kernplasma" —"The chlorophyll bands unite by their ends"—and then goes on to say of the feature that evidently interested him most, "the cell nuclei of both cells, however, become dissolved; the copulation product is without a nucleus." Two years later, Schmitz (1879), when studying hematoxylin-stained material of this alga, was more fortunate. He saw the two nuclei in the zygote, as he says, "approach nearer and nearer, come into contact and finally fuse to a single nucleus." This observation by Schmitz is an important one, for in it we have the first clear statement that the nucleus of the male cell passes over intact to the female cell, there to fuse with the female nucleus.

Strasburger had, it is true, seen a second nucleus fusing with that of the egg in the archegonia of *Picea* and *Pinus* in 1877. He did not, however, really know the source of this second nucleus, though he suspected some relation to those that are present earlier in the tip of the pollen tube. These tube nuclei

THE MALE PUMPKIN FLOWER

At the left the brilliant yellow blossom is shown slightly enlarged and cut open, with one side of its broad trumpet let down. At the right, much more enlarged, is the anther column covered with dark golden yellow pollen grains, some of which have already fallen and may be seen sticking to the white column. The pumpkin is monoecious—that is, male and female organs are borne in separate flowers, but on the same plant; while the date palm (fig. 2) is dioecious, the male and female flowers being borne on separate plants, and the tobacco (fig. 5) is hermaphrodite, the staminate (male) and pistillate (female) organs being united in the same flower. (Fig. 7.)



PUMPKIN POLLEN PRODUCTION

The male flower, stripped of its petals and highly enlarged. The anthers are designated by *a* and the filaments (combined into a column) by *b*. The anthers are just bursting and the narrow, labyrinthine slits reveal the pollen grains inside. The swollen base of the stamens is hollow and has been cut open so that one can see through it, in order to make its construction clear. (Fig. 8.)

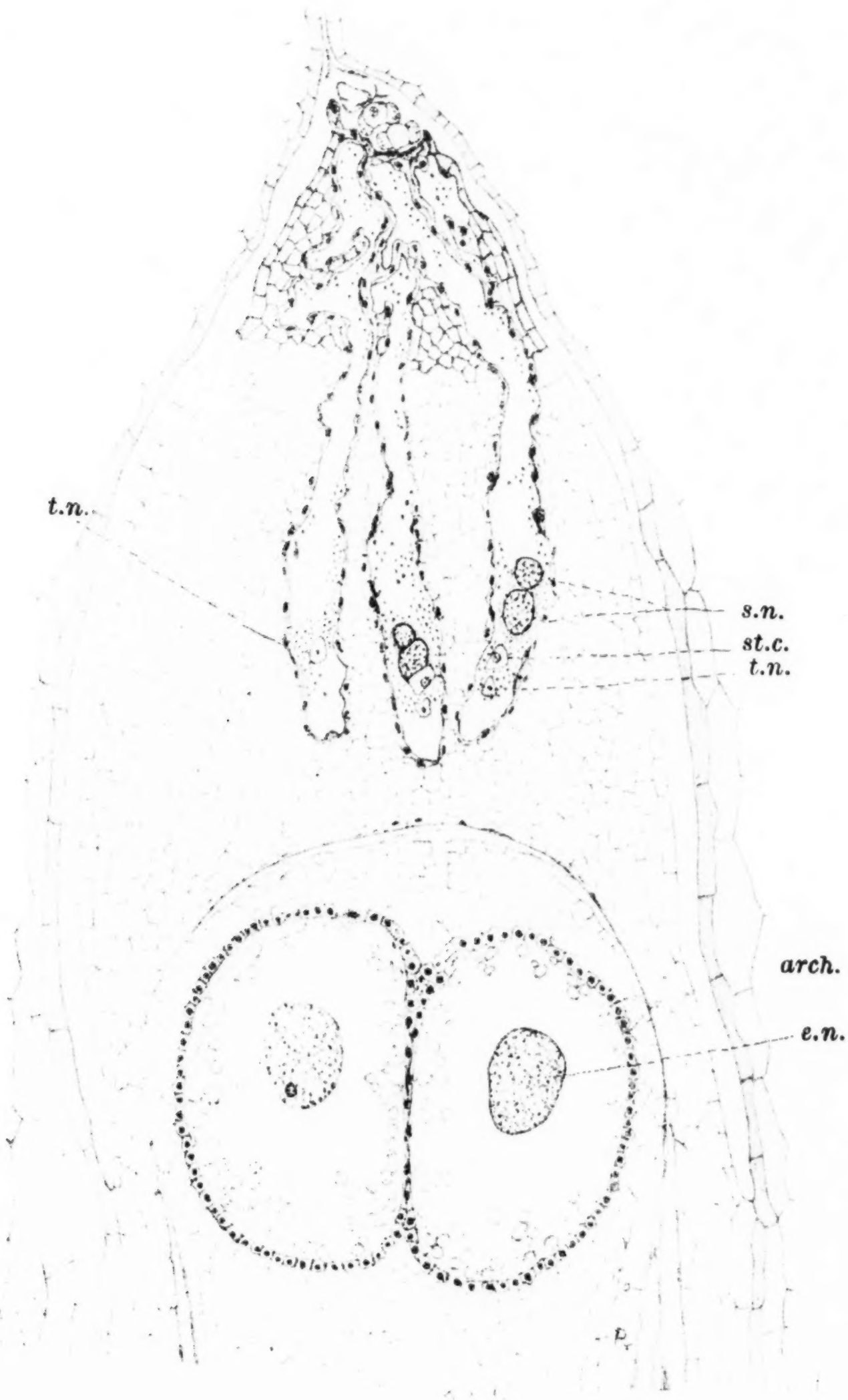
STIGMA OF A PUMPKIN FLOWER

It is upon the rough, sticky surface of this irregular body that the male pollen grains fall and germinate. Each one sends out a tube which grows down into the tissue of the stigma (see the following figure) and finally reaches the ovary which lies below. The nucleus of the pollen grain slips down this tube, comes in contact with one of the ovules in the ovary and unites with it, thus fertilizing it and permitting it to grow into a pumpkin seed. Photograph much enlarged. (Fig. 9.)

he says are dissolved just before fertilization, and then just after fertilization, to quote (1877):

"The male nucleus *formed from the contents of the pollen tube* is found now near the end of the tube, now near, or in contact with, the egg nucleus. . . . The protoplasmic contents of the pollen tube, I hold, passes through the (imperforate) tube-membrane in a diosmotic manner."

The fertilization of the gymnosperms, because of their large eggs, pollen tubes and nuclei, was at this time being studied by a number of workers. One of these, Goroschankin, in 1883, was able to demonstrate that in *Pinus pumilio* the pollen tube opens at the end, and that through this pore the two male cells pass bodily into the egg. Goroschankin's mistake, in supposing both male nuclei to fuse with the egg nucleus, was corrected by Strasburger the following year. The latter (1884) saw the same bodily exit of both male nuclei from the *open* pollen tube of *Picea*, but found only one male nucleus fusing with that of the egg. In the same publication Stras-



HOW THE POLLEN TUBES GROW

Vertical section of ovule of a pine, shortly before fertilization; magnified about 100 diameters. Three pollen tubes can be seen growing down from the micropyle, the narrow channel at the top by which they entered. *s.n.* is the sperm nucleus, *t.n.* the tube nucleus, *st. c.* a stalk-cell. There are two archegonia (*arch.*) or egg cells, each with its egg nucleus (*e.n.*). When a sperm nucleus from one of the pollen tubes finally reaches one of these egg nuclei, it will unite with and fertilize it, thus initiating the development of the seed. After Ferguson, *Life History of Pinus*, Washington, 1904. (Fig. 10.)

burger also records numerous instances in which he had been able to observe the same mode of escape of the contents of the pollen tube into the ripe embryo sac in angiosperms. At last, as Strasburger puts it, in discussing fertilization in the conifers:

"The most important morphological facts are clear. It is established that the male nucleus that copulates with the egg nucleus, passes *as such* out of the pollen tube into the egg."

Thus, finally, was the actual material contribution of both parents to the embryo of the seed plants first seen. This was just two centuries, lacking a decade, after Camerarius (1694) had proven that the presence of pollen on the stigma is indispensable to seed-formation. One chief reason why this important problem so long baffled all investigators was the lack of proper methods of preparing material for study. The older method of studying unfixed and unstained sections had certain advantages, it is true. The sequence of developmental stages was often determined with certainty by actually following their succession in living material under the microscope, and there was less cause also for dispute about artifacts. But structures of the same refractive qualities were not readily distinguished in such sections. As Strasburger himself says (1884, p. 18):

"The negative results of my earlier studies and of those of Elfving were due to the lack of a method which permitted the nuclei to be distinguished in the strongly refractive contents of the pollen tube up to the moment of fertilization."

That these studies of 1884 were successful was largely due to the use of material fixed in .5% acetic acid, 1% osmic acid or absolute alcohol, and stained in borax carmine, hematoxylin or iodine green.

The extreme significance of the fact that those most highly organized portions of the cell substance—the nuclei—were so prominent in the process of fertilization was at once appreciated by Strasburger, who in 1884 announced the following general conclusions as the outcome of his consideration of the phenomena observed:

"(1) The fertilization process depends upon the copulation with the egg nucleus of the male nucleus that is brought into the egg, which is in accord with the view clearly expressed by O. Hertwig. (2) The cytoplasm is not concerned in the process of fertilization. (3) The sperm nucleus like the egg nucleus is a true cell nucleus."

In the years since 1884 the nuclei have been found to be the structures chiefly concerned in fertilization, whenever such a process occurs. Among the earlier observations of this nuclear union at fertilization in each of the great groups are the following, named in the order of discovery: It was seen in *Pilularia* (Campbell, 1888), in *Riella* (Kruch, 1891), in *Œdogonium* (Klebahn, 1892), in the plant rusts (Dangeard and Sapin-Trouffy, 1893), in the toad-stools (Wager, 1893), in the red alga *Nemalion* (Wille, 1894), in *Sphærotheca* (Harper, 1895), in the rockweed, *Fucus* (Farmer and Williams, 1896). Finally Zederbauer (1904) reported it for the Peridineæ, and Jahn (1907), Olive (1907) and Kraenzlin (1907) made it out in the myxomycetes.

The observations just referred to, and many others on plants in all groups, warrant the general application of Strasburger's conclusion that a nuclear union is the characteristic feature of every sexual process. The few cases where the male cytoplasm seems more prominent than usual, as in the three conifers studied by Coker (1903), Coulter and Land (1905) and Nichols (1910), can not yet be said to have rendered it very probable that this cytoplasm plays a primary part as an inheritance carrier.

PREPOTENCY

A Quality Belonging to Characters Rather Than Individuals—Something More Than a Result of Inbreeding—Linkage or Coupling of Separate Factors in Heredity Explains Observed Prepotency, and the Difference Between "Breeders of Breeders" and "Breeders of Performers."

EDWARD N. WENTWORTH

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ACCORDING to the opinion of leading live stock men, the chief essential to success in breeding is the possession of prepotent breeding animals (particularly sires). Very few of these men will attempt to explain what this prepotency is and fewer still can give more than an extremely fragmentary idea. Yet the fact is self-evident to the student of pedigrees that there are marked differences among breeding animals, since only 3 to 5% of the breeding stock existing a few generations back is represented in the tables of ancestry of the present-day individuals.

Just what factors are responsible for this condition? Without doubt, fashion and advertising play an important part in determining the blood lines that shall survive, but the breeder in final analysis is a business man demanding performance, and as has been shown in numerous studies,[1] there is actual difference in the breeding power of individuals. Davenport in his "Principles of Breeding" sums up a distinction common among practical breeders when he points out "breeders of breeders" and "breeders of performers," or those that transmit performance through more than one generation and those that simply confer the good qualities upon their offspring.

It has been customary in defining prepotency to state the manner in which the breeder thinks it occurs. According to popular idea, prepotency depends upon the presence of a "high percentage of blood" of some particular individual. The means by which prepotency is brought about is by a supposed narrowing of the bloodlines, either through inbreeding, linebreeding, or some form of pedigree selection. Prepotency is assumed to be the result of a cumulative effect of ancestry. In correspondence conducted by the writer a few years ago to obtain prevalent ideas on the nature of prepotency, the following communication was received from Dean Eugene Davenport of the University of Illinois. It is of interest in that it very clearly expresses the popular idea on the subject.

"Prepotency, of course, is a corollary of the law of ancestral heredity. That parent that has behind him the largest mass of back ancestry selected to the same characters, will, of course, be prepotent. If you take the series of fractions, ½, ¼, ⅛, etc., and divide them by 2, representing the contribution of the sire and dam, you will obtain the possibilities of each expressed in fractional form so far as prepotency is concerned. . . . If, now, all the individuals represented by these fractions have been selected to the same standard, then, of course, the sire himself backed by his ancestors will control one-half of the possibilities of the offspring, regardless of what the female will be. Of course this same would be true for the female under like conditions. This, it seems to me, *is the essence of prepotency, and it is all there is of it.*" [2]

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[1] "Distribution of Prepotency," Francis Galton. Nature LVIII, 246-247. "Principles of Breeding," Eugene Davenport. Pp. 551-567. "Prepotency of Different Plants," W. W. Tracy. Proc. Soc. Prom. Agr. Sci. 1900, pp. 57-59. "Result of Selecting Fluctuating Variations," F. M. Surface, Conf. Internationale Génétique 1911, pp. 221-256.

[2] The italics are mine.

While this idea is widely held by animal husbandmen, the man who has conducted genetic experiments and watched the segregation of individual factors cannot help but feel that the conception is manifestly outside of the facts. The behavior of hereditary characters as though controlled by unit factors in the germ plasm leaves no room for a cumulative effect of ancestry (unless the increased opportunities tc bring about homozygosis through selection in hereditarily limited stock be thus considered).

NATURE OF THE GERM PLASM.

Even the parent himself has no effect on his progeny in an hereditary way, as inheritance does not really consist in the passing on of characters from one generation to the next. The similar characters of parent and progeny develop because both parent and progeny arise from qualitatively the same germplasm (as far as the particular characters are concerned). When one mixes lime chloride and sulphuric acid he will obtain lime sulphate and muriatic acid. These are the end products of the reaction. If he sets apart a portion of the lime chloride and sulphuric acid the first day and a few days later mixes them, he will get the same result. The results of the first day have no effect on the results of the later day. When the germ cell of the animal begins development it corresponds to the first chemicals, the developed body to the end-product of the reaction. Characters that are alike in parent and offspring arise because they come from similar origin, but the body, an end-product of development, no more affects the germ cells that produce the progeny, than the end-products of the chemical reaction affected the reaction of the later day. This shows by analogy how far outside the facts of inheritance the conception of a cumulative ancestry lies.

To indicate the principal difference between the prepotent and non-prepotent sire, the roan Belgian referred to by the writer in a previous paper, that sired only red roan colts (256 in number) from various colors of mares may be compared to another roan Belgian therein mentioned that produced about half roan colts and the other half grays, bays, browns, blacks and chestnuts. Obviously the first horse was the more prepotent of the two. He must have transmitted red roan in every germ cell. To do this, he must have been homozygous or pure for the dominant characters of roan pattern and bay color; that is, he must have received both roan and bay from sire and from dam. While there is no way of exactly determining what was transmitted in the germ cell, the fact that both parents were bay (red) roans[3] and that only bay roan colts were produced would show that there was only one chance out of approximately 18,062,500,000,000,000,000 that the assumption is wrong.

The second horse, on the other hand, was sired by a blue roan stallion out of a bay mare. This indicates at once that he cannot be homozygous for roan since he received it from only one parent, nor could he be pure for bay since it came only from the dam. Yet he sired about 50% of red roans and blue roans, a performance which some breeders might also consider prepotent.

PREPOTENCY AND PURE BREEDING.

This indicates the first essential of prepotency, homozygosis in a dominant character. Of course, the breeder believes that prepotency is a property of the individual and not of the character. But in almost every instance the idea of prepotency is based on some superficial and striking character like color, and it is assumed that since this character appears with fair uniformity, the rest of the characters must appear also. As a matter of fact, it is highly improbable that there ever occurred the ideally prepotent animal described by the breeder; that is, one which is able to impress most of his characters upon his progeny in spite of the females to which he is mated. The livestock man reads with interest of that great line of Clydesdale sires from Darnley down through Topgallant, Sir Everard, the

[3] There are two classes of red roans corresponding to bays and chestnuts, but each carrying the roan pattern.

long lived and redoubtable Baron's Pride, the $47,500 Baron o' Buchlyvie, and the sensational five-year-old sire, Dunure Footprint; each a son of the animal preceding and, with the exception of Topgallant, each a distinct step in advance of his progenitor, as far as siring prize winners is concerned. Here is an exceptionally prepotent line, because all but Topgallant were the leading sires of Scotland during their tenure in stud. Yet even these great horses begot a percentage of failures that is startlingly large, even though smaller than that of any other line of sires in any breed. Prepotency is never a property of the individual, but belongs to a certain few characters that are part of the hereditary makeup of the individual, and their condition as to homozygosis or heterozygosis is the entire determining factor. The degree by which one animal is more "strongly bred" for a character than another animal is this wide degree of purity or hybridity.

EXISTS IN BOTH SEXES.

Many breeders deny the existence of prepotency in the female, and consider it entirely a property of the male sex. This belief has come about as a result of two conditions. Since in all domestic breeds polygamy is practiced, it is obvious that a smaller number of males is required than females. This admits of a more stringent selection in one sex than in the other, and increases the chances of the male's having both greater numbers of homozygous characters and also more desirable combinations of characters. Furthermore, in uniparous races, such as the horse and ox (the species in which the art of animal breeding has largely been developed), there is only one individual in a season that may be compared to a female, while numerous individuals occur that may resemble the male. Where there is much diversity among the females, the fact that only one out of the season's progeny may show resemblance to any particular female, while numbers may partake of the characters borne by the sire, is bound to over-emphasize the importance of the male as far as hereditary influence is concerned.

Thus far the discussion has applied only to simple qualitative characters that depend on relatively few and easily recognizable factors. When one approaches quantitative characters such as size, vigor, etc., from which dominance is probably absent, the problem becomes more complex. It seems very doubtful if the principle differs here, but the presence of larger numbers of factors or of factors for greater development must be assumed to take the place of the dominant factors already discussed. At least the writer does not believe that there are two schemes of heredity involved in inheritance, and since one has been found to hold in the qualitative characters, and since the data assembled on quantitative characters seem to follow the same system as far as they have been investigated, it is no more than logical to make the preceding assumption.

Another cause of prepotency in quantitative characters may arise where the male bears one factor necessary to link up the factors in the female to produce the desired character. Thus, in the ordinary white mouse, the base for pigment production, a factor denoted by C, is lacking. In one variety of Japanese waltzing mouse, white with faint yellow marks, Darbishire found the factors for agouti, black and chocolate missing and the yellow diminished quantitatively. Yet the progeny of the cross were agouti, because the Japanese variety supplied the color base which the white mice lacked. While the prepotent animal usually breeds true for its character, this extreme case is interesting because it shows how one individual may supply the one factor necessary to a relatively uniform somatic expression. Breed history records many prepotent sires that bred better than themselves. Perhaps the trotter George Wilkes and the Shorthorn Champion of England would fall in this class.

LINKAGE OF CHARACTERS.

Emphasis has been laid on the usual custom of declaring prepotency on the

basis of some striking superficial character. Attention was directed to the fact that it is probable in the main that this character is transmitted alone and independently of other characters, yet such need not by any means be the case, since the phenomenon of linkage and coupling assures us of a mechanism whereby totally unrelated characters physiologically may be part of one hereditary complex. Thus T. H. Morgan and his associates have demonstrated in the pomace-fly, Drosophila, the tendency of miniature wings, yellow body, and white eyes to be grouped together, in segregating out of crosses with the normal fly that has the gray body, red eyes, and long wings. Many other combinations of similarly linked characters have also appeared in their work, some linked to sex as the characters just mentioned, and some uninfluenced by the sex determining factor. They have interpreted these results on the basis of the factors in the germ cells that produce these characters somatically, having practically a common locus (probably a chromosome). If such be the case in the domestic mammals, and there is no more reason for doubting it with them than with Drosophila, there is really a genetic foundation for the belief of the breeder that the superficial characters on which the degree of prepotency is determined also indicate the transmission of other characters, at least characters that find their origin at the same germ locus (chromosome).

As a result of this, one can see very clearly that the distinction between the "breeder of breeders" and the "breeder of performers" is almost entirely a question of character linkage, the "breeder of performers" ending his function when he has contributed a number of characters to his progeny, so distributed among different hereditary complexes that the segregations in germ cell formation separate the necessary interacting factors. The "breeder of breeders" must bear his factors that interact to produce performers in one hereditary complex only. The "breeder of performers" possibly has similar factors to the "breeder of breeders," but they are located in two or more complexes, thus permitting segregation and separation.

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Origin of Shetland Ponies

"The Making of the Shetland Pony" is discussed by J. Cossar Ewart as an appendix to "The Shetland Pony" by Charles and Anne Douglas (Edinburgh and London: W. Blackwood and Sons, 1913). He comes to the conclusion that "Shetland ponies are mainly descended from the 'small and fleet' race yoked to the chariots of the Caledonians at the battle of Mons Graupius. This ancient race, again, was probably to begin with a blend of the slender-limbed, Arab-like ponies of the Swiss lake-dwellers, and of a thick-set race of the elephant-bed [a fossil deposit near Brighton] type." Their small size he explains as follows: "If Shetland ponies have not sprung from a small wild pigmy race, it may be safely asserted that their small size is mainly due to isolation in small areas where they were forced to shift for themselves under, as a rule, extremely unfavourable conditions."

LIVE-STOCK GENETICS

Review of the Work in Experimental Animal Breeding, Now Under Way at the Various Agricultural Experiment Stations in the United States.

THE RESEARCH COMMITTEE ON ANIMAL BREEDING

BREEDING domesticated animals for research in genetics is restricted by the great expense it involves, the long generations, and the small number of individuals produced at a generation, not to mention other difficulties. Genetists have therefore used plants for experiment, wherever it appeared that a problem could be solved equally well in either medium. Furthermore, a good many lines of experimental animal breeding do not lend themselves to any immediate end of economic importance. For these reasons, the agricultural experiment stations in the United States have gone into this line of research only to a limited extent, and some of the work they have done is little known as compared with the purely experimental and more fully reported investigations made at universities and other institutions.

In order that the contribution which the experiment stations are making to genetics may be appreciated, the Research Committee on Animal Breeding of the American Genetic Association presents the following report, reviewing part of their work. No doubt it will be found that some important lines of investigation have been omitted; and to save space the committee has ignored many breeding projects, some of them on a large scale, which have for their purpose the improvement of a breed by the same method used by farmers and ranchmen, and which are likely to throw little, if any, new light on the laws of heredity. Experiments of this nature often take up most of the attention of genetists who work with live-stock at the experiment stations, and their economic importance is very great, but a review of them was thought to be of little interest in this Journal.

Probably no station has made more contributions to the theory of animal breeding than has that of Maine, whose department of biology, organized in 1907, is directed by Raymond Pearl, and whose staff includes 10 associates and assistants and a number of graduate students. To date 72 papers have appeared from this laboratory, most of them dealing with some phase of genetics. Among the problems now under investigation is the important one of the inheritance of fecundity in poultry, to which some notable contributions have already been made. "Two definite and clear-cut results have already come to light. These are:

"First: that the record of egg production or fecundity of a hen is not of itself a criterion of any value whatsoever from which to predict the probable egg production of her female progeny. An analysis of the records of production of large numbers of birds shows beyond any possibility of doubt that, in general, there is no correlation between the egg production of individuals and either their ancestors or their progeny.

"Second: that, notwithstanding the fact just mentioned, fecundity is, in some manner or other, inherited in the domestic fowl. This must clearly be so, to mention but a single reason, because it has been possible to isolate and propagate from a mixed flock 'pedigree lines' or strains of birds which breed true, generation after generation, to definite degrees of fecundity."

This interesting conclusion was reached after the failure of a long-continued experiment to increase the egg-production of hens by simple "mass selection." As to the real solution, Pearl thinks the capacity for high egg production is inherited through the sire rather than the dam, experiments having shown that high egg producing hens

and low ones produced daughters having the same grade of egg productivity, when mated to the same cock. If this be the true result, it is obvious that poultrymen should seek above all to secure cocks from strains noted for their high egg records and obtain hens from these cocks for high egg production. Pearl further attributes the fecundity of the breeds of fowl studied by him to three distinct Mendelian factors, one of which is sex-linked. The study of sex-linked characters—that is characters which are transmitted through the male to half of his grandsons, or through the female to her sons, etc., is being carried on at the station along many lines.

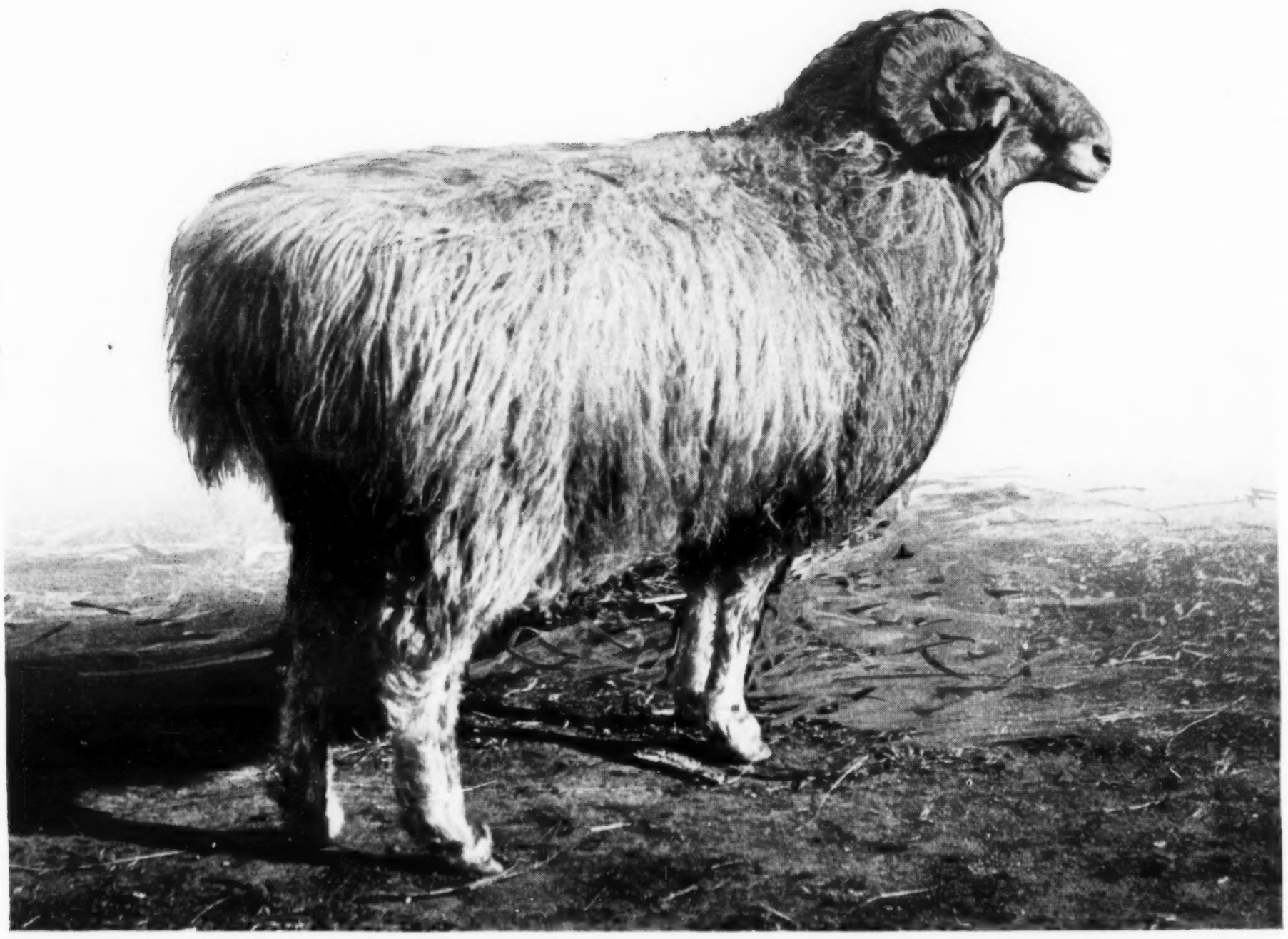
INBREEDING.

Considerable theoretical contributions to the subject of inbreeding have been made from this station, one of them being a mathematical method of measuring the intensity of inbreeding. The practical breeder has been content to say, in measuring the amount of inbreeding of a descendant of the Shorthorn bull Ringmaster, let us suppose, that a certain calf was "seven-eighths Ringmaster blood." This statement, however, does not give any definite idea of the pedigree of the calf; European zootechnists therefore evolved the count of so-called "free generations" which is a good practical measurement and easily understood. If, for example, Ringmaster appeared three generations back in the calf's male line, and two generations back in the line through the dam, there are two free generations on the male side and one on the female; adding these together, the calf is said to have three free generations, in respect to Ringmaster. It has been found, to carry the matter a step further, that most winning English racehorses during the last half century have had five free generations; prior to that, four free generations was the rule. When there are no free generations, Thoroughbreds are likely to be deficient in vigor (a result commonly attributed to high inbreeding), when there are more than five free generations, they fail because their speed (the product largely of inbreeding) has been swamped by outcrossing, or lost by reversion.

Pearl proposes to measure the degree of inbreeding of any individual algebraically, by calculating the possible number of ancestors in previous generations and comparing this number with the number actually found in the animal's pedigree. By the use of some such accurate measurement as this (which is described and illustrated in bulletins 215 and 218 of the Maine station) a further study of inbreeding will be much more practicable, and should throw light on one of the most fundamental and debated problems of practical genetics.

That a certain amount of inbreeding is advantageous in the maintenance of blooded stock is now generally admitted; that an excessive amount is dangerous is also pretty widely believed. Pearl, like a great many other genetists, thinks the question of degree, *in itself*, is of secondary importance, the real question being the quality of the animals inbred. The Maine station has issued the following counsel to breeders:

"That a mating of such close relatives [as brother and sister or parent and offspring] will surely result in disaster is one of the carefully nursed superstitions of breeding, which has often been exploded but will doubtless always be with us. It may be said that all the evidence which may be gleaned from the experience of stock breeders indicates that the results which follow inbreeding depend entirely on the nature of the individuals bred. If one inbreeds weak animals, lacking in constitutional vigor, and carrying the determinants of undesirable qualities in their germ cells, the offspring resulting from such a mating will undoubtedly be more nearly worthless than their parents. If, on the other hand, one inbreeds in the same way strong and vigorous animals, high in vitality and carrying the germinal determiners of desirable qualities, there may be expected a corresponding intensification of these qualities in the offspring. The time has come when a vigorous protest should be made against the indiscriminating condemnation of inbreeding. It should be clearly recog-



SIRE OF A NEW BREED

Pure-bred fat-rumped ram from Siberia, owned by the South Dakota Agricultural Experiment Station, and expected to aid in the production of a type of sheep that will be able to withstand the severe winters of that state successfully. The Fatrump breeds of Siberia are noted for their hardiness: when the food supply is entirely cut off by snow, they are able to subsist for some time on the fat stored in the rump. It is hoped that this valuable characteristic can be retained in the hybrids bred in the United States. (Fig. 11.)

nized that if the experience of stock-breeders extending throughout the world, and as far back as trustworthy data are available, means anything at all it plainly indicates that some degree of inbreeding is *essential* to the attainment of the highest degree of success in the breeding of animals, poultry forming no exception to this rule."[1]

STUDIES OF CATTLE.

At the Massachusetts station an attempt is being made to work out a comprehensive correlation between Dairy Form of cattle (as called for in the show ring, and in text books) and butter-fat and milk production. This work is necessarily statistical and includes complete measurements of a large number of cows on which production records have been maintained for three or more years. The object is twofold: to seek a clue to the mode of inheritance of milk and butter-fat production in dairy cattle, and to determine whether the present standards of judging dairy cattle are really based on sound genetic knowledge. Studies in the inheritance of coat color in mammals are also under way, and furnish material for an incidental inves-

[1] "Of course," Pearl notes, "if the term *inbreeding* makes too violent a strain upon anyone's intellectual, moral or merely human prejudices, there is no objection to his using for the practice the term *line-breeding*, or some other even milder designation."

tigation of the effect of inbreeding on fertility.

At the Massachusetts station the poultry department is using both fowls and ducks in an endeavor to get as much genetic information as possible, the principal point under consideration being the inheritance of fecundity. An investigation is also being carried out on the inheritance of hatching power of eggs, of comb form, color and color patterns, shank feathering and rate of growth. Some of the latter researches parallel those that have been made by Bateson, Davenport and other investigators, the Massachusetts station desiring to confirm or apply their results, and to find satisfactory interpretations for the new facts observed.

Influence of management and feeding on vigor of germ in hen's eggs has been investigated in West Virginia. The data already in hand indicate that chicks are less vigorous when hatched from eggs laid by hens which have been laying heavily for a long time.

A study of inheritance in the honey bee has been pursued in Texas for several years.

The Porto Rico station is improving native cattle by crosses with zebu hybrids brought from Texas.

As a result of hybridizing wild and tame cavies for past six years, the Illinois station has reached some interesting conclusions which have just been published by the Carnegie Institution of Washington[2] (publication no. 205). The investigators are convinced that the Mendelian mode of inheritance prevails for individual characters in species crosses in mammals in the same way as in variety crosses, contrary to what has sometimes been asserted. Many different characters have been studied and their mode of inheritance is reported in this paper. Fertility in the male hybrids seems to be a very complex character which segregates out in the Mendelian fashion. At present work of selection and hybridization is under way with mice and other small mammals. There has been room for plenty of more practical work, for over a million cows are kept for dairy purposes in Illinois, of which not more than 2% are purebred. The station has induced many breeders to add purebred bulls to their herds and is endeavoring to get as many cows as possible accurately tested, although at present only a fraction of 1% of the total number can show accurate records of production, kept either officially or privately. "It should be considered little less than a crime to use a scrub bull, or one whose dam has not produced 300 lbs. of butter fat in 365 days," the breeders are told, and they are gradually taking the advice to heart.

TO PRODUCE BROWN EGGS

By crossing suitable breeds, the Maryland station has undertaken to produce a breed of general utility fowl that will lay a white shelled egg. The superior market value of the white egg over that with a brown shell is well known; and although the preference seems to be wholly irrational, breeders must be prepared to meet the situation. Unfortunately the breeds that lay white eggs are, as a rule, small and ill adapted for marketing. It should be possible to transfer the capacity to produce white shelled eggs (which seems to be a Mendelian character) to a breed that will also make good "broilers." It is this task which the Maryland station has undertaken.

Heredity in sheep is being studied in New Hampshire, observations on the mode of inheritance in horns having already been published. In cattle, the polled condition seems to be a regular Mendelian dominant except that, according to Spillman, the dominance is not entirely complete in male heterozygotes. In sheep, the inheritance of horns does not follow the same rules, although it is thought by many students to follow an equally simple system. The New Hampshire station has worked principally with Merinos, and in order to interpret its data has postulated two "determiners" in the germ cell, the behavior of which differs in each sex, and has also postulated the presence of hypothetical "inhibitors," which further

[2] Most of the actual breeding, results of which are reported in this publication, was done at the Bussey Institution, Forest Hills, Mass.

complicate the explanation of its findings.

Crossing Tunisian sheep with native breeds, and with Shropshires, Oxfords, Hampshires and Rambouillets, has been under way for several years at the Arizona station. There are now more than 150 rams bred by the station, from one-half to one-eighth Tunis, in use in Arizona, which means that about 10,000 lambs containing Tunis blood are produced each year. They are not only particularly hardy and vigorous, but have proved of great value in eradicating Johnson grass (*Andropogon halepensis*) along the irrigating ditches.

MULE BREEDING.

The breeding of mules is being studied in Mississippi from almost every possible aspect. Influence of the type, size and quality of sire and dam respectively, on offspring are being watched, the fertility of the mule is being investigated in a search for that apparently more or less mythical "fertile mule" which is reported in live-stock publications at constant intervals, along with the equally mysterious "sheep-goat hybrid" for which every breeder has probably sought with interest at some time in his experience. Finally, the relative qualities of mules and hinnies are tested and measured.

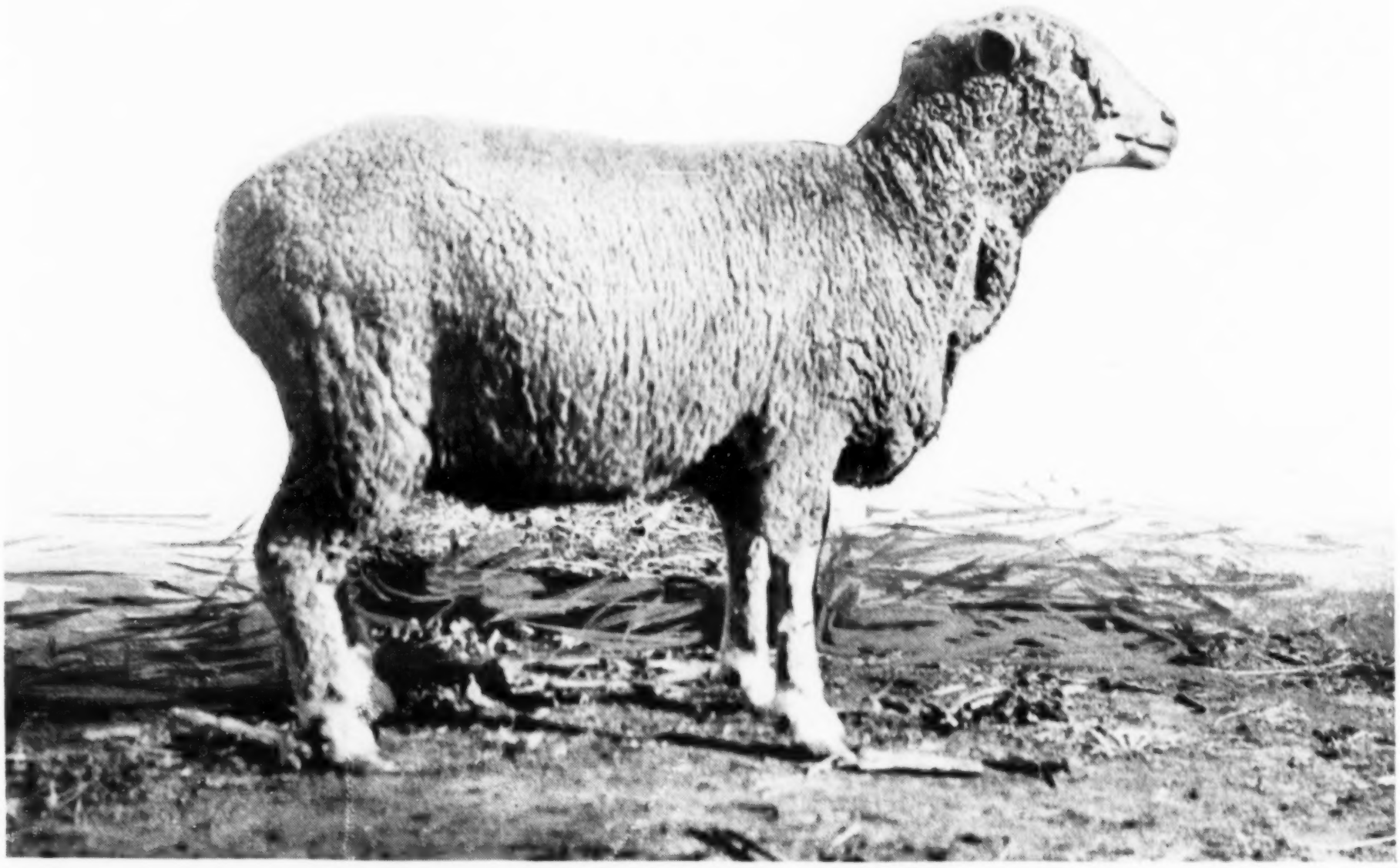
The supposed existence of "racial poisons" is being submitted to rigorous scientific test in Wisconsin. It has long been admitted that certain poisons —as well as unfavorable conditions—to which a mother is exposed during pregnancy might injure the offspring, but there has been more doubt as to the effect of similar factors on the father, although it has been widely believed that alcohol and lead poisoning might influence the reproductive capacity of the male. After treating male rabbits with lead and alcohol, Leon J. Cole has compared their offspring with those of normal males. "What appear to be decisive results have already been obtained. In the case of alcoholic poisoning of the male the most marked result has been a lessening of his efficiency as a sire, the alcohol apparently having had some effect on the vitality of his spermatozoa. The 'leaded' males, on the other hand, have produced as many or more offspring than the normal fathers, but their young have averaged smaller in size and are of lowered vitality, so that larger numbers of them die off at an early age than is the case with those from untreated fathers." Such results, like the earlier ones of Stockard with guinea pigs, must not be interpreted as meaning that exactly the same thing occurs in man, but strong presumption is at least raised as to the actual existence of "racial poisons," which the eugenist must investigate directly in his human material.

The inheritance of various characters is being pursued exhaustively in pigeons, particularly with a view to working out the heredity of the small color differences which are so important to fanciers; the physiology of reproduction is also being studied. Tri-coat color in guinea-pigs, one of the favorite subjects for genetic analysis, has been taken up, while the effects of inbreeding are being noted in fowls, and the inheritance of color in Rhode Island Reds is made the particular subject of investigation. Inheritance of certain peculiarities in the reactions of rats to definite rations is being investigated, and finally, the inheritance of unit characters in cattle has been attacked in a project that will require many years for completion. Two very distinct breeds, the Jersey and the Angus, are being cross-bred, and in addition to merely superficial points, the behavior of such hereditary characters as total milk production, percentage of fat, size and shape of oil globules, viscosity and other properties of fat, rate of growth and form of animal's body are being watched.

The Delaware station has for six years been studying the effect of close breeding in pigs, and has now begun the same work with Guernsey cattle. As results in investigation of this subject are slow in appearing, the station can not yet publish any conclusions.

GRADING UP THE SCRUBS.

The grading up of a flock of scrub fowls is being carried on in a systematic way at the North Dakota station, by the



PURE-BRED RAMBOUILLET EWE

The Rambouillet is a French improvement of the Spanish Merino, in which fineness of wool has been particularly developed but in which mutton quality has also received careful consideration. The breed is comparatively resistant to parasites, is long-lived, can travel a long distance for feed and water, and instinctively herds closely. It is hoped that these valuable characteristics can be retained in the cross with the Siberian fat-rump, and greater hardiness gained. The ewe here shown is owned by the South Dakota Agricultural Experiment Station, and is the dam of the lamb shown in the following cut. (Fig. 12.)

use of Plymouth Rock males. Such a method of improving live stock has long been in use among cattle breeders, but the precise results to be expected when it is followed by poultry breeders are not so well known. The experiment is planned to yield information on this point. A carefully recorded experiment in grading up western range Merino sheep is also on foot.

How the white belt characteristic of Hampshire swine is inherited is being studied by the Iowa station, by cross and pure breedings. The slow work of studying heredity in cattle was taken up eight years ago, when a number of black polled Galloway females were bred to a white, horned, Shorthorn male. A considerable number of F_2 animals have been obtained and the study of inheritance of coat color and of the polled condition is well under way. An investigation of the significance of scurs in cattle is about to start.

The Ohio station is slowly accumulating data which will eventually provide material for analysis. The principal study in hand is that of the respective influence of sire and dam upon wool production, both in the grease and scoured, of the progeny; also upon the rate of gain and size of progeny. Individual laying records of Leghorn hens and their progeny are being kept and some cross-breeding in poultry done. The Department of Dairy Husbandry is just starting a study of the effects of long-continued inbreeding of dairy cattle

FAT-RUMP RAMBOUILLET LAMB

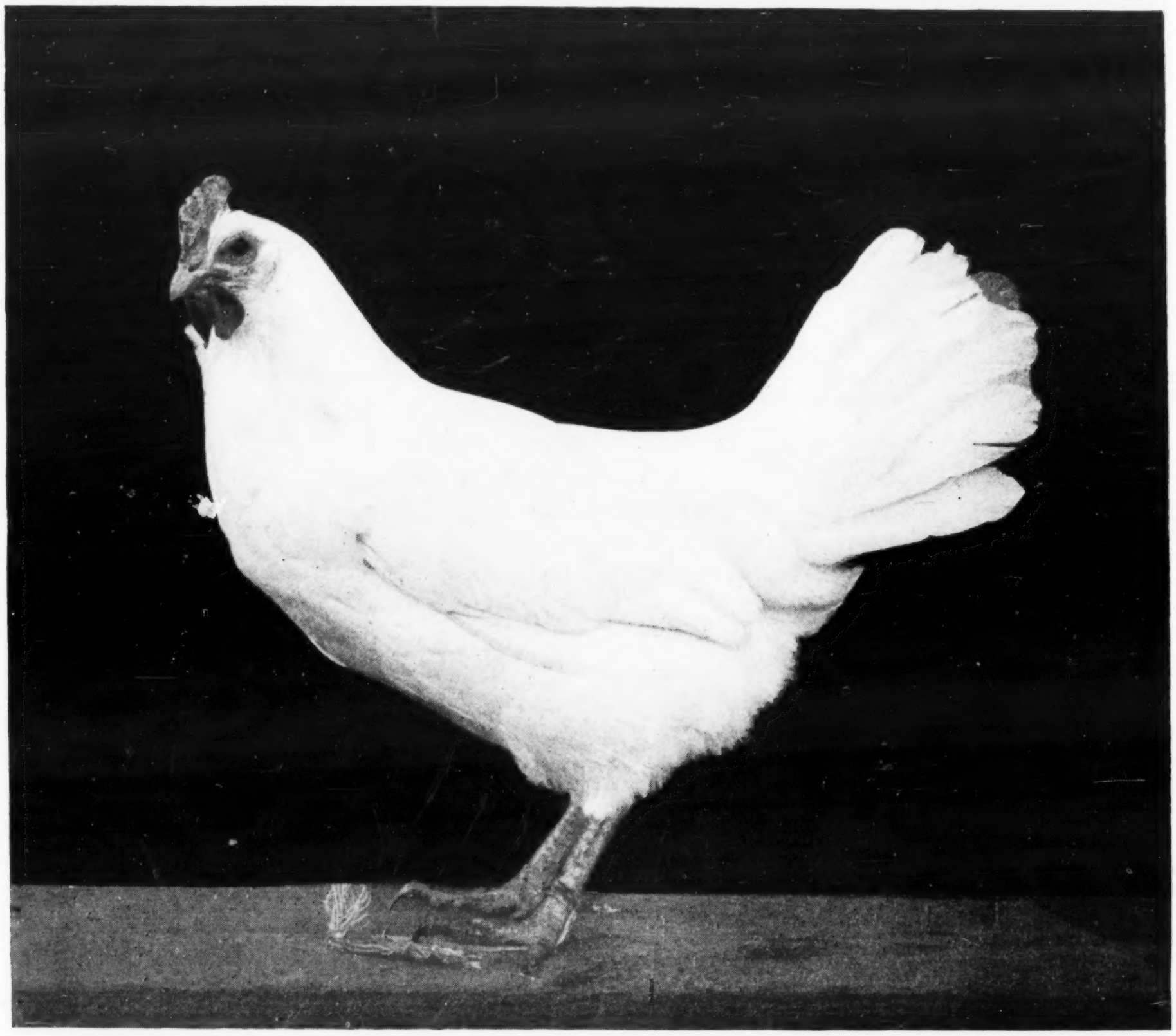
The first product of the attempt at the South Dakota Agricultural Experiment Station to breed a valuable type of sheep that will flourish in deep snow. This lamb was two and one-half months old when photographed. The tail is somewhat reduced in size from that of the maternal (Rambouillet) stock, and it is hoped to get rid of it altogether, and substitute a development of fat as in the paternal stock. (Fig. 13.)

on the form, size, vigor, production, etc., using Jerseys and Holstein-Friesians.

Creation of new breeds of sheep for the semi-arid conditions of the northwest has been undertaken by the South Dakota station, with the fat-rump sheep which N. E. Hansen brought back from Turkestan last summer. They will be crossed principally with the Down breeds. "We have the first crossbred lamb of this breed," Director James W. Wilson reports, "and I do not believe there is another sheep in the United States exactly like it. I intend to eliminate the tails in the crossbreeds and increase the development of the rumps so that the new breeds will be able to withstand the deep snows that we get frequently in the winter time on the range, when sheep can not get anything to eat. At this time they will live on the fat stored up in their rumps. These sheep came from the home of the camel and are noted for their endurance of hardships." Observations are also being made on the relation of feed and care of parents to the condition of offspring.

A NEW BREED OF FOWLS

Rather striking success has been produced in the Rhode Island station's study of inheritance in poultry. "The aim of this study has been to produce 'barring' as a result of crossing pure-bred black with pure-bred white fowls; and then to ascertain whether the manifestation of barring can be accounted for by any known methods of inheritance." A barred race has actually been pro-



A PHENOMENAL EGG PRODUCER

Queen Utana, a Single Comb White Leghorn hen bred and owned by the Utah Agricultural Experiment Station. In five years she laid 816 eggs, a record which her owner thinks has never been equaled. She is one of a flock in which the Utah station is studying the inheritance of egg production. (Fig. 14.)

duced; it is evident, then, that an unsuspected factor for barring is carried latent in the germinal constitution of White Leghorns, the white parent used in the experiment.

Inheritance of egg weight is also being tested, the data appearing to show that any individual fowl lays eggs which vary only slightly from a certain average weight. Comparison with the record of the mother indicates that the weight of an egg is a character which is actually transmitted from one generation to another; the observers are now trying to find out how.

A parallel to the classic selection experiment of W. E. Castle on hooded rats is under way at the Rhode Island station with rabbits, in which material an attempt is being made to influence, by selection, what is known as the "English pattern." Selection is made of both plus and minus variations in each generation, in order to discover whether selection produces a cumulative effect, and can modify a character, which is recognized as a Mendelian unit. Should the experiment produce that result, it will add confirmation to the claim of Castle and others, that so-called unit characters are not the immutable things that they have some-

times been supposed to be, but that they are capable, within certain limits, of actual change by selection.[3]

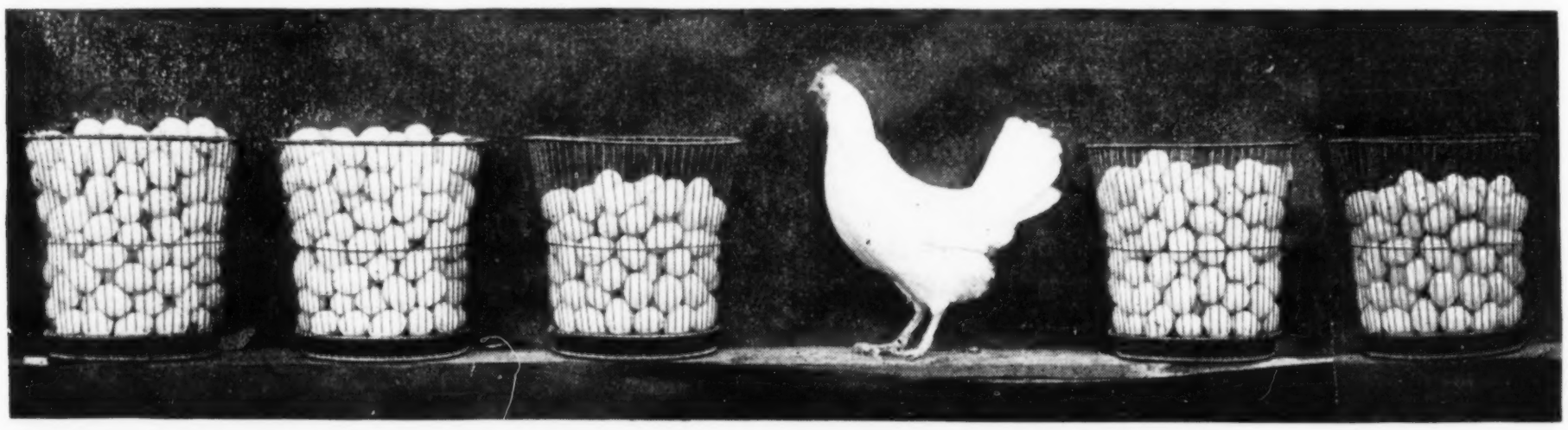
The inheritance of egg production is a subject for study in New Jersey, where an attempt is being made on an adequate scale to breed a strain of fowls that will vindicate the genetist's claim that he can control this character. In this connection the question of close inbreeding is being studied. At present, the experiment is being run on two lines, one dealing with birds of high capacity and the other with low producers. It is by interbreeding these two lines that light is sought on the problems of heredity. General studies of inheritance have also been undertaken by the crossing of White Leghorns and Black Langshans, interesting facts about the source of barred pattern and the inheritance of black pigment having already come to light.

Coat color in horses has been extensively studied at the Kentucky station, a report of results appearing recently in the JOURNAL OF HEREDITY, under the name of W. S. Anderson. The breeding of dairy cows from a scientific point of view is also under way.

PREPOTENCY.

The Kansas station, in its department of animal husbandry, is just starting an experiment to determine the relation of ancestry to prepotency. It is hoped that six years of experimental breeding will throw some light on the very important practical question of prepotency, about which at present the average breeder has usually vague and often incorrect ideas. The object of the study will be to measure the relation of cumulative effect of ancestry to character transmission in color, weight and size of bone; and to observe the type of inheritance of (a) preorbital brachycephalic face, (b) number of nipples, (c) fertility, (d) meat type as related to sex.

The department of zoology of the Kansas station is working with more technical subjects, one of which is the breeding of grasshoppers to determine the laws of inheritance in them. This work, Robert K. Nabours writes, "shows clearly the Mendelian type of inheritance, and the essential result of these experiments has been the extension of this principle to a considerable number of types" of a group of insects that is very low in the evolutionary scale. An attempt is now being made to find whether there is some correlation between the hereditary behavior of these



QUEEN UTANA AND HER PRODUCE

In the first year of her test, she laid 195 eggs, in the second year 193, third year 138, fourth year 161, fifth year 128; total production in five years 816 eggs. The Utah station believes tests of egg production which extend only over a year or two are likely to furnish misleading results, and is accordingly testing each hen as long as practicable. So far these tests have failed to confirm the belief that the inheritance of the egg-laying character is Mendelian in nature. (Fig. 15.)

[3] On the other hand, several experimenters have shown that these results can be fully accounted for on the hypothesis of multiple factors. If this explanation is accepted, it means that the supposed unit character, which was modified by selection, is not an ultimate and indivisible unit at all, but an aggregate of a number of smaller units, which usually hang together, but may split up in certain crosses.

grasshoppers, and the chromosome complex of their germ-cells.

The crosses of Zebu with native cattle have been studied from a genetic point of view by this department, and a cooperative experiment in the inheritance behavior of crosses of Karakul and Lincoln sheep has been started.

From the Utah station, Director E. D. Ball writes:

"By breeding fowls, we are attempting to determine the possibility of improvement of the laying qualities of hens by continuous selection. In order to accomplish this it was considered necessary first to establish what the original laying capacity of an unselected flock of hens really was, as study of all of the records available did not seem to throw very much light on this question. Most of the records have been based entirely on the first year production, and the first year production as is shown in our Bulletin 135, appears to be a very poor indication of the laying capacity of a given individual or of a given strain of fowls. Therefore, the first object sought was to keep a sufficient number of flocks of unselected fowls under as near as possible normal conditions, to determine through a series of years what production could be normally expected from a flock and what the range of variation due to seasonal influences, individual differences, etc., really was. Bulletin 135 contains a summary of this work to date. It will be continued for some time in order to get still more accurate data and especially to determine the actual longevity and laying period of the White Leghorn hen.

PERIODICAL EGG RECORDS.

"This year's records, which are not included in this bulletin, are strikingly confirmatory of the general results. The records this year under identical care and attention of last year have fallen almost to the poor record of 1911, while every indication up to date is that next year's record will again be a good one, more forcibly illustrating the periodicity in production. We have in manuscript at the present time a detailed study of the winter egg production of these same flocks of hens in an attempt to determine whether there is any possibility of discovering a Mendelian factor, as is claimed by the Maine Station. We have been unable to find any Mendelism in the inheritance of this characteristic. Taking the records of hens from three to seven years and comparing them, we find that the individual fluctuates up and down in the same way that the flocks do, and that our winter egg production is even more variable than our total, that entire flocks have produced as low as 15 to 17 eggs in the first winter and from 35 to 40 the second year. According to Dr. Pearl's conclusion, it would seem that they must have acquired the high laying unit the second year. A third portion of this bulletin will take up the possibilities of improvement by selection,—it is, of course, only a preliminary study as it will be necessary to carry on the work many years to obviate seasonal variations and to select strains. We have, however, been able materially to modify productions by strain selection based on three years or more of production, and tested by an equal amount of production in the offspring."

A series of experiments of far-reaching importance, which should attract the attention of eugenists as well as livestock breeders, is under way at Missouri. "The influence of the age of the parents upon the offspring is at the present time largely a matter of opinion. A careful study is being made of the ultimate effect of mating young animals continuously. It is proposed to determine first the effect upon the immediate offspring; second the effect upon the mother; third the effect, if any, upon the race. Some interesting results have already been secured, particularly upon the effect of early mating upon the mother and immediate offspring." "The most important positive result is apparently the stunting effect on the young mother. Careful measurements indicate that early pregnancy interferes with the rate of growth and the ultimate development of the maternal parent." Several hundred animals are included in this experiment to date.

Sex-linked characters are being traced in poultry, where they have been found

particularly abundant in plumage pattern. The spangled pattern of the Silver Spangled Hamburg, for instance, is found to be sex-linked but, curiously enough, it is not transmitted as a unit for the entire body, the tail seeming to follow a scheme of distribution of its own; for in all reciprocal crosses, the tails of the F_1 birds are solid black. A correlation between the hen feathering characteristic of male Sebright bantams, and diminished fertility, is being sought by a series of bantam crosses.

Heredity scores another victory in its popular contest with environment, as the result of nutrition tests on cows. "The development of dairy heifers on different planes of nutrition, which has been under investigation for the past seven years, has resulted in some interesting facts. The results indicate that the method of feeding can influence the size, age of maturity and conformation of the dairy cow to some extent. The milk secreting function, however, does not seem to be influenced to any marked degree, if at all, by any ordinary variation in treatment. The milking function is inherited and cannot be influenced to any great extent by the ration the animal receives when young."

Eugenics Congress Postponed

The executive committee of the Second International Eugenics Congress has sent out the following notice:

"On account of the situation in Europe and America created by the Great War, the Executive Committee for the Second Eugenics Congress has regretfully decided that it will be impossible to hold the proposed Congress in September, 1915. The existing organization will be maintained, pending the reestablishment of settled conditions, when the Committee will determine upon a new date.

"The Executive Committee asks for the continued interest of those who have consented to serve as members of the several committees and as officers of the proposed Congress."

The Determination of Sex

Leonard Doncaster of Cambridge University contributes to *Nature* (October 1, 1914) a note on his breeding experiments with the gall-fly. It is well known that many Cynipid gall-flies have two generations in the year, one generation of parthenogenetic females and a second generation of males and sexual females. He has previously shown that any individual parthenogenetic female has either only male or only female offspring, and that the eggs of the male-producers undergo maturation of a different type from those of the female-producers. He suggested the possibility that the difference depended on the existence of two kinds of spermatozoa, but now finds this a mistake and decides that the "difference between the male-producing and female-producing females is derived from the sexual female parent." This type of sex-determination has not previously been known in the Hymenoptera, but the examination of over 9,000 flies bred make the experimenter certain "that nearly, if not quite, all the grandchildren of any sexual female are of one sex, and that of the sexual females, those which have male or female grandchildren are about equally numerous."

FEEBLEMINDEDNESS

A Serious Problem to Eugenists—Two-thirds Due to Heredity—Many Grades of Arrested Development, Shading Imperceptibly Into Normal Population—Manner of Inheritance.

A Review by the Editor.

TO THE eugenist, no problem is more immediate and serious than that of feeblemindedness. Ever since eugenics became a recognized science, its followers have devoted to feeblemindedness what many have thought was an altogether disproportionate amount of time. With added knowledge, the problem has increased rather then decreased in complexity and urgency. It is still far from being settled, but the past year has seen studies which do much to dispel the fog; and among these the most noteworthy by far is the work[1] of Dr. H. H. Goddard, director of the research laboratory of the Training School at Vineland, New Jersey, for feebleminded boys and girls. As a result of five years of research, Dr. Goddard is able to present detailed pedigrees of 327 children in the institution, nearly all of them representing at least three generations. They are sufficiently complete, it appears, to furnish material from which anyone who cares to investigate can draw his own conclusions.

Feeblemindedness has been defined as "a state of mental defect existing from birth or from an early age and due to incomplete or abnormal development in consequence of which the person affected is incapable of performing his duties as a member of society in the position of life to which he is born." It is, in other words, merely a state of arrested mental development (with some physical abnormalities in the lower grades), and is thus easily distinguished from insanity, which is a disordered rather than an arrested development of the mind. The feebleminded are for convenience classed as idiots, imbeciles or morons, according to the point at which their development was arrested, the idiot being one whose mental age is two years or less, as measured by such a test as the Binet scale.[2] An imbecile may have a development of from three to seven years, mentally, while the term "moron" in the United States designates one whose mental age is from eight to twelve years. As a fact, the moron class shades off imperceptibly into the normal bulk of society.

DEFECTIVES NUMEROUS.

The amount of feeblemindedness in the community is much larger than anyone suspects who has not investigated conditions. In the United States Goddard thinks there are between 300,000 and 400,000 feebleminded persons, but the distribution is very irregular; in some communities few are to be found, while in the state of New York alone the number has been placed as high as 30,000. These figures refer only to the feebleminded who can actually be distinguished as such—the "patent" individuals. The number of "latent" individuals, those not actually feebleminded themselves but carriers of the defect in their germ-plasm and capable of passing it on to their descendants, is necessarily vastly larger.

The taint, then, is so widespread that the student of heredity is amply justified in looking on it as the most important cacogenic factor in the community.

[1] Feeblemindedness, its Causes and Consequences, by Henry Herbert Goddard, Ph. D. Pp. xii + 599, price $4.00 net. New York, The Macmillan Company, 1914.

[2] Every eugenist should be familiar with the principles of the Binet test, which has often been described. "The Binet-Simon Measuring Scale for Intelligence," by H. H. Goddard, is sold by the Training School, Vineland, N. J., for 15 cents. See also "Tests for Mental Defect," by Dr. Howard A. Knox, in the JOURNAL OF HEREDITY, V, 3, 122, March, 1914.

Fortunately, however, not all feeblemindedness is due to heredity. Just how much is due to other causes, no one can say: Goddard thinks that one-third of the cases examined in his work at Vineland may be ascribed to some other cause than inheritance. These appear to be due in some cases to a neuropathic ancestry, in others to accident before, at, or after birth, in others to some disease such as scarlet fever or spinal meningitis, during childhood. Cases of such origin are not transmitted to offspring, and therefore are of little importance to the genetist. By no means all cases where accidents are blamed for feeblemindedness are really due to that cause, it appears, further investigation showing enough feeblemindedness in the ancestry fully to account for the child's condition; on the other hand, the fact that a certain child is left feebleminded by an attack of disease, while a dozen others who have it at the same time escape unscathed, indicates that here too a weakness of some sort in the family stock may explain the resulting arrest of mental development in the particular case.

There are a number of supposed causes of feeblemindedness which Goddard finds to have little reality, as far as his own experience goes. Thus there seems reason to doubt that parents' alcoholism arrests the child's mental development to the extent of leaving it among the feebleminded. Paralysis, epilepsy, insanity or syphilis in the parents seem of themselves insufficient to account for a child's feeblemindedness; neither can tuberculosis or consanguineous marriage explain such a result. Where these things occur, they occur not as causes, but as corrollaries or effects, of a defective germ-plasm.

THE "CRIMINAL TYPE"

On the other hand, feeblemindedness itself is at the bottom of an amount of social abnormality which the ordinary sociologist—much less the layman—rarely realizes. The so-called "criminal type," Goddard believes, is merely a type of feeblemindedness, a type misunderstood and mistreated, driven into criminality for which he is well fitted by nature. The chronic alcoholic is often to be explained by an arrest of mental development, rather than by original sin or moral perversity. The prostitute, in from one-fourth to two-thirds of the cases investigated in different cities, is found to be feebleminded, and should be humanely segregated rather than punished or "reformed." The ne'er-do-wells of a community are usually found, if adequately tested, to be morons; the adult vagrant and the confirmed child truant usually belong to the same type. The expensive "special classes" of the public schools are filled with children a large part of whom are morons; an attempt is made to educate them, when an examination of their ancestry would show that it is humanly impossible to educate them, in the way that their playmates are educated. In fact, such tests as those of Binet, wherever applied, have rarely failed to show that the number of social problems whose solution lies with genetics rather than with ordinary sociology is far greater than anyone except the eugenist realizes.

Unfortunately, the exact rôle of heredity in any given case can only be found by an investigation of the pedigree—a labor that involves much expense and time as well as the indispensable aid of a skilled field worker. Nay, the very presence of feeblemindedness is often ignored, and an individual blamed for perversity, incompetence or stupidity, when the examination of a trained psychologist would show a discrepancy between mental age and physical age. The lower grades, the idiots and imbeciles, can indeed be distinguished by almost anyone, but the moron, particularly of the higher grade, is detected only by the careful observation of a competent investigator equipped with psychological tests and experience in using them. And even there, one finds a border line where one can not with confidence say whether the subject is normal or abnormal—these words being merely relative terms without exact definition.

"The feebleminded in bulk—if we exclude special types of idiots—are not

a special race, sharply differentiated from normal-minded folk," says Karl Pearson. "There is every grade of feeblemindedness . . . and as far as mentality is concerned no sharp line can be drawn across the population, and those on one side of it treated as normal and those on the other as mentally defective,"—a statement of the case that I think Goddard and most other students would accept.

This fact of continuity has an important bearing on all work with the feebleminded as a class. To the student of heredity it is particularly important, because most of the present-day studies of heredity start with the assumption that each character inherited is a unit. Can we speak of a unit character, when it shades off imperceptibly into another —can we call feeblemindedness a unit, when no line can be drawn between it and its supposed alternative or "allelomorph," a normal mind?

THE UNIT CHARACTER QUESTION

This question has caused bitter disagreement among eugenists. The earlier students of the subject assumed that it was a unit character and interpreted their pedigrees in that light. They called it a recessive trait, normal mentality being dominant. From the very beginning, psychologists had on the whole refused to assent to this proposition. Goddard himself "confesses to being one of those psychologists who find it hard to accept the idea that the intelligence even *acts like a unit character*," although his own figures force him to say that "there seems to be no way to escape such a conclusion." But the question was not really made a crucial one among genetists until the publication of three bulletins from the Galton Laboratory of London, devoted largely to an attack on exactly this feature of recent American work in eugenics.

In the first one,[3] Dr. Heron, the assistant director, devoted himself wholly to a destructive criticism of studies which considered mental defect from a Mendelian viewpoint—which assumed, in short, that feeblemindedness was a unit character and so behaved in inheritance. He was answered[4] by some of the men he attacked; but as the controversy was fairly well aired in the daily as well as the scientific press, it will not be renewed here.

Following this came another contribution from London,[5] in which measurements of the intelligence of school children in Stockholm were presented to prove that feeblemindedness was not a unit character but showed continuity with the normal population. Still later Karl Pearson published in the same series a lecture[6] reviewing the whole situation, and pointing out the need for some accurate measurement of the higher grades of mental deficiency. "That a real measure will be found—short of the experimental method of testing actual success or failure in the rough and tumble of life—I am convinced," he concludes, "but I doubt whether it has been found at present and its discovery will not be expedited by any scientific dogma that asserts all mental defect is of one kind, and is due to the absence of a determiner, a lack which the feebleminded share with our ape-like ancestors."[7]

[3] Mendelism and the Problem of Mental Defect. I. A Criticism of Recent American Work, by David Heron, D. Sc. Pp. 62, price 2 s. net. London, Dulau and Company, 1913.

[4] Eugenics Record Office Bulletin No. 11. Reply to the Criticism of Recent American Work by Dr. Heron of the Galton Laboratory, by C. B. Davenport and A. J. Rosanoff. A Discussion of the Methods and Results of Dr. Heron's Critique, by C. B. Davenport; Mendelism and Neuropathic Heredity, by A. J. Rosanoff, M. D. Pp. 44, price 10 cents. Cold Spring Harbor, Long Island, N. Y., February, 1914.

[5] Mendelism and the Problem of Mental Defect. II. The Continuity of Mental Defect, by Karl Pearson, F. R. S., and Gustav A. Jaederholm, Ph. D. Price 1 s. net. London, Dulau and Company, 1914.

[6] Mendelism and the Problem of Mental Defect. III. On the Graduated Character of Mental Defect and on the Need for Standardizing Judgments as to the Grade of Social Inefficiency Which Shall Involve Segregation, by Karl Pearson, F. R. S. Pp. 51, price 2 s. net. London, Dulau and Company, 1914.

[7] This refers to the suggestion of C. B. Davenport (see *Popular Science Monthly*, January,

The smoke of controversial battle must not obscure from the public the fact that as to the hereditary nature of much if not most feeblemindedness there is no doubt. This alone would suffice to justify a eugenic campaign. The further question of how it is inherited is purely a technical one. Nevertheless, it is one which has great importance, to society as well as to the professional genetist. What, then, is the layman to think about the way in which this condition is transmitted?

It seems impossible to overlook the ease with which the puzzle can be explained by the hypothesis that feeblemindedness is due to not one but many unit characters, which in general, *but not always*, cling together in a group, when transmitted. When they stick together in one group, they produce the appearance of a single unit character, and thus yield the approximate Mendelian proportions which Goddard found when he tabulated his matings, and which his predecessors also found in their researches. But when some other factor comes into play, this group may be broken up and only a part of the units passed on to a given individual. They may be enough in number to produce obvious feeblemindedness; they may be so few that the individual who receives them appears, in any ordinary environment, to be little inferior to his comrades.[8]

NEED FOR MORE RESEARCH.

If this hypothesis be the true explanation of the behavior of feeblemindedness in heredity, the antagonism between the biometrists with their insistence on continuity and the Mendelians, with their insistence on the unit character, is only apparent. Neither side at present accepts such a solution, but it seems probable that the further prosecution of genetic studies will result in a more general acceptance of the idea that supposed unit characters are multiple and that visible traits are complex in nature.

But as I have already said, we must not get so much interested in a question of secondary importance as to forget the point of first importance—namely, that feeblemindedness is a widespread defect, largely due to heredity, which threatens to lower the intellectual level of the whole race unless careful selection in mating keeps it from infecting more sound stock each year. As feeblemindedness involves a lack of self-control and an inability to understand ethical questions, the possessor of it can not be expected voluntarily to take any steps which will prevent the transmission of his defect. With society is the responsibility for protecting itself.

But, the opponents of eugenics object, Nature will take care of the whole matter. These diseased conditions of the germ-plasm "run out;" the stream always tends to purify itself. "A study of the charts here presented," Dr. Goddard remarks, "will hardly be found reassuring in this direction." In the absence of any interference, the number of feebleminded usually becomes larger with each generation; if they are of the very lowest grade, it is true that they leave no descendants, but among the morons the taint is more likely to spread than not. And even in cases where it seems to have died out, where no feeblemindedness appears for three or four generations, we can not be sure that the condition has not become merely latent. The genetist, indeed, who has seen exactly analogous cases in his breeding experiments, will feel quite sure that it is merely latent, ready to appear again when the proper mating is made. There is no safeguard for society in a dependence on some

1912) that feeblemindedness is a survival of the mentality that characterized the ape-man: that the condition has been carried down unchanged in the stream of germ-plasm ever since.

[8] For a clear statement of this hypothesis see "Nature of Mendelian Units" by G. N. Collins, JOURNAL OF HEREDITY, V, 10, 425, October, 1914. This hypothesis will also harmonize the conflicting views on albinism in man, where the same statistics are interpreted by biometricians to show continuity and by Mendelians to show segregation of a unit character. See the statement of the two sides of the case in the JOURNAL OF HEREDITY, V, 11, November, 1914: "Albinism in Man" (a review of the work of the Galton Laboratory) by A. E. Hamilton and "The Laws of Naudin-Mendel" by Dr. E. Apert.

mystical help from Nature; it must protect itself by deliberate intervention.

At present society fulfils this obligation in a very inadequate manner, by segregating, in some states, a small part of the most hopeless grades of defectives. Even then, they are not always prevented from propagating their kind. There is general agreement that effective segregation should be extended, but it is of course difficult to say who should and who should not be included. Pearson thinks that it is merely "a matter of practical utility where we draw the line which shall legally define mental defect for purposes of segregation. It certainly should not be done under four years' mental defect judged by adequate Binet tests. This will only cut off about 20 to 30% of those at present classed as feebleminded in the special schools. The remaining 70 or 80% may be, and probably are, incapable of fending for themselves in ordinary life; they are also socially inefficient, but ultimately, on other grounds, temperamental or moral, not merely intellectual: they take a view of life which is in distorted perspective, and they are out of harmony with their economic or social surroundings. They may be more dangerous than those in whom true *mental* defect is far greater, and they may more urgently stand in need of segregation," because while the groveling idiot is unlikely to become a parent, the moron is almost certain to do so, either legitimately or illegitimately, unless prevented by society from doing so.

How shall this restraint be exercised? In the first place, says Dr. Goddard, as many of the high grade defectives as possible must be effectively "segregated" in their own homes, by the intelligent action of their own relatives. As to the rest, the lower grades must obviously be gathered together in colonies, not only for the protection of society, but for their own protection. But if the higher grades are to be included, it will mean the establishment of at least a thousand colonies, each containing 300 or 400 individuals—a burden which the nation is not likely to assume at present.

"The facts," to Dr. Goddard, "show that we must colonize as many of the feebleminded as we possibly can, that we must sterilize some, and then we discover that we have only tithed the problem, we have not solved it." The rest—all of them, of course, representing the higher grades—should, he says, be educated.

Impossible?

"That depends on our definition of education," he answers. They can be trained, if recognized and taken in hand at an early enough age, to do many kinds of work which do not demand the possession of judgment or real intelligence, but which depend rather on habit. Few of them can be taught usefully to read, write, or count, but there are many kinds of manual labor that they can be trained to do with sufficient proficiency to pay for their cost of maintenance. Even should the community find itself unable to stop altogether the production of this class, at present, "may it not be possible that we will find use for all these people of moderate intelligence, and that the production of so many high grade feebleminded is only the production of so many more people who are able and willing to do much of the drudgery of the world, which other people will not do?"

There remains a question of first importance to the eugenist—the relation to marriage selection of the moron who is left at liberty. Here students sometimes seem to fall into no more than two classes: those who propose wholesale sterilization, and those who propose nothing. Dr. Goddard takes a middle course, thinking sterilization adequate to dispose of "a narrow zone" of cases; for the rest, it appears that general education of the public to realize that morons exist in large numbers, in all classes of society, and that they can not by outward appearance be detected, will do much, perhaps all that is possible, to abolish the problem. When the man or woman contemplating marriage realizes the desirability of investigating the ancestry of a prospective mate, the infection of sound stocks by marriage between normal persons and high-grade morons or those who, wholly normal in themselves, are carriers of latent feeblemindedness, will largely cease.

SUPERIORITY OF THE ELDEST

Investigation Among Professors in Italian Universities Shows that the First-born Are Most Frequent Among Them, While Children Born Late in the Generation Are the Rarest.[1]

CORRADO GINI
Professor of Statistics in the University of Padua, Italy.

ON SEVERAL occasions I have called the attention of readers of this Review to the importance of the study of the characteristics of children with relation to their order of birth in a fraternity. The importance is double:

(1) to determine whether the privileges accorded in so much past legislation and some even at the present day, to the first-born, are justified;

(2) to judge what consequences the habit, widely gaining ground, of limiting the size of a family, will have on the quality of future generations.

Before or after me, numerous authors have considered the question: Pearson, Heron, Macaulay, Weinberg, Crzellitzer, March, Ploetz, Hansen, Goring, Greenwood, Jr., Yule, Cobb, Rivers.[2] Some think defects and abnormalities are more frequent in the first-born; others, of whom I am one, dispute the correctness of the methods followed in many cases, and the consequent validity of the conclusions.

Often, indeed, a pessimistic conclusion about the quality of the first-born has been announced, as a result of the observation that defects and abnormalities were particularly frequent among the first-born, or that eldest children were found most frequently among defectives and abnormals, without taking into consideration the fact that such a result might be due not to the fact that in a given family the eldest were inferior to their successors but to the circumstance that the sick and abnormal are most common in small families, which furnish no children except those that are of relatively low birth-rank. In some way, then, it is necessary to elimate from the calculations the influence of family-fecundity, if we are to get a clear view of the influence of birth-rank.

But there is another point to consider. If in an investigation correctly carried out, it were shown that the first-born present bad characters more frequently than their brothers, still it would not be demonstrated that they are, on the average, inferior. It might be explained by the assumption that the eldest are merely more variable, and that they more frequently show in an extreme form either bad characters—or good ones.[3] Investigations on the distribution of maladies and abnormalities according to birth-rank ought to be followed by direct investigations on the distribution according to birth-rank, in single families, of the persons who excel in physical or mental characters. On this point the only observations hitherto made, so far as I know,[4] are the inadequate ones of Axenfeld and Robinovitch, based on insufficient numbers, and contradictory in their results.

The best way to fill up this lacuna

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[1] Translated from Rivista Italiana di Sociologia, Anno XVIII, fasc. II, Marzo-Aprile, 1914.

[2] For the most recent contribution to the subject see Chase, John H., Weakness of Eldest Sons. JOURNAL OF HEREDITY, V, 5, 209, May, 1914.—The Editor.

[3] This is the explanation offered by Havelock Ellis in Hereditary Genius, for the fact that many of England's most talented men have been eldest sons.—The Editor.

[4] Alexander Graham Bell has investigated the inheritance of longevity in nearly 3,000 cases. His figures (not yet published) show the first two children to be almost exactly average, as far as longevity is concerned. Beyond them the curve rises, and the next two children are superior to the average, the fifth child is again average, while the later children—from the sixth on—show an inferior longevity.—The Editor.

in our knowledge is to address to all the persons who excel in any particular walk of life, either by physical or mental powers, a simple questionnaire containing questions like this:

(1) How many children had your parents?

(2) Among these children what is your own order of birth?

A questionnaire of this sort, signed by Sig. F. Floris, laureate in jurisprudence at the royal university of Cagliari, and by myself, was sent out during the present year to all the professors in Italian universities. We received 445 replies, of which 416 related to families containing at least two children, and therefore of value to this investigation. They show (a) how the professors in Italian universities are distributed in regard to birth-rank; and (b) whether, in a given family, the frequency of attainment of a university professorship is independent of the birth-rank, or whether it varies with the latter, and if so, in which sense.

The second column of the following table answers the first question. The 141 first-born professors came from 416 families with at least two children, and 29 each of whom is an "only child" ought to be added; one thus obtains a total of 170 first-born professors among the 445 families which furnished university professors. Column 4 answers the second question: I take the actual number of professors for each birth-rank as 100, and thus obtain the theoretical number which we would have gotten if, in each family, the quota of professors furnished was quite independent of birth-rank.

The actual number of university professors is thus seen to be greater than theoretical expectation among the first born and less than expectation among the cadets: compared with theory, the difference is seen to be the less, the higher the birth-rank of the individual.

Taking into consideration the rigorous system, based on competition, by which entry to an Italian university is regulated, it must be admitted that the Italian university professors represent a stringently selected group of the population, and it can not be doubted that their intellectual level is, on the average, notably above that of the class from which they spring. It seems fair to conclude, therefore, that the first-born, at least so far as concerns scientific attainment, are superior to their juniors and that, among these latter, the last-born are inferior to their predecessors.

Two objections particularly can be urged against these conclusions.

(a) Women rarely aspire to a university career. To decide the influence of birth-rank on scientific attainment, we should therefore restrict our inquiry to the number of male children born to

Order in generation.	*a* Number of professors from families of at least two children.	*b* Theoretical number on the hypothesis that distribution of professors is independent of order of birth.	$\frac{100a}{b}$
1	141	87.4	161
2	82	87.4	90
3	58	69.9	83
4	45	54.2	83
5	32	38.7	83
6–7	31	44.9	79
8–9	20	19.8	79
10 upward	7	13.4	52
Total	416	415.7	100

the parents of the person addressed, and to his own birth-rank among these males.

I reply that the proportion of the sexes does not vary much with the birth-rank, and that its slight variation could not possibly change the regular diminution, according to birth-rank, of the figures in column 4. It must be remembered that we paid no attention, in our questionnaire, to the sex of the professors addressed (an omission made desirable by the need of simplifying the demands as much as possible), and that this omission can have no other influence than to make the influence of the birth-rank appear attenuated, in the results.

(b) The frequency of professors among the first-born is favored by family circumstances, and in particular by the desire of parents to see their eldest child occupy a position that will reflect honor on the family. Quite apart from biological influences, among the various categories of children, social influences might thus explain the greater abundance of professors among the first-born.

This objection must receive careful consideration; yet the fact remains that the relation of actual number of professors to theoretical calculation, even among the younger children, diminishes *regularly* as the order of birth-rank increases.

The conclusion that the first-born are superior to their juniors, at least so far as concerns scientific attainment, must nevertheless be accepted under reserve, until further data allow us to clear away all doubt. This result will probably be attained after similar questionnaires have been sent to other categories of persons, distinguished physically or mentally, among whom social considerations in the family would not act, or at least would not act in the same way, as among university professors. The investigation reported above must not be taken—nor do I describe it—as more than a first step destined to be followed, in case of success, by more elaborate questionnaires among other classes of persons eminent in all branches of human activity: in the literary, artistic, military, bureaucratic, commercial, financial, political, and athletic fields.

Adopting our idea, the Italian Committee for the Study of Eugenics has included in its program the carrying out of these investigations. The importance of this organization, and of the object of the study, ought to result in as numerous replies to further inquiries as have honored our first essay.

The Proper Age For Marriage

The intellectual qualities of the children produced must largely decide the question whether early or late marriages are the most desirable from a eugenic point of view, according to Dr. Värting, who has recently published[1] a study of 75 distinguished Germans, whose parentage he has investigated. He comes to the somewhat unusual conclusion that the marriage of a young man with a woman of mature years is likely to produce the most talented children: 24 years he selects as the minimum age at which girls should wed, and 30 as the age beyond which a man ought not to venture into matrimony. Aside from the inadequate number of cases with which he deals, Dr. Värting's conclusions hardly seem justified by his material, particularly since more than half of the fathers of distinguished sons listed by him were more than 30 years of age at the birth of the son in question. His ascription of Nitzsche's insanity to the youth of his mother (18 years) can be matched by the fact that Frau Aja was only 19 when she bore Wolfgang von Goethe. On the whole, the book can not be considered a very substantial contribution to the interesting and important subject, which has been handled by Redfield in America in a far more worthy way.

[1] Das günstigste elterliche Zeugungsalter für die geistigen Fähigkeiten der Nachkommen. Pp. 63, Würzburg, 1913, C. Kabitzsch, M. 1.20.

A NEW WALNUT

Mutant Somewhat Similar to Live Oak Appears in California in Four Different Localities—Not a Walnut-Oak Hybrid—Origin of All Walnut Species Possibly by Mutation.

ERNEST B. BABCOCK

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IN THE spring of 1901, in a southern California nursery owned by D. C. Disher, there appeared a dozen or more seedlings, the first recorded specimens of a new form of the native California Black Walnut, *Juglans californica* Wats. Two of these trees still remain where they were first transplanted from the seed bed while several were given away and are now growing at various places in California. The two that remain on the site of their origin have been described and named[1] as a new variety, *quercina*, because the general appearance of these trees, with their small, dark green leaves, is somewhat like that of the California Coast Live Oak, *Quercus agrifolia* Née. Fig. 16 shows these trees as they appeared in 1907. Their similarity to oaks is not in specific details but in general appearance, in spite of the fact that this same form has been named,[2] but without a proper botanical description, "*Juglans quercifolia*" by another writer. I maintain that *the leaves are not oak-like in form*, which is the important mark of resemblance. Neither are they closely similar in size, which is quite variable, nor in color and texture, which are distinct from live oak as well as from black walnut. Fig. 17 illustrates most of these points, while fig. 18 shows that the fruits of *quercina* are simply reduced black walnuts.

This lack of resemblance between the new form of walnut and the live oak is an important point when we consider the claim set forth that this form is a natural hybrid between walnut and oak. It happened that the wild black walnut tree which was the parent of the original specimens of the new form, stood beside a large Coast Live Oak tree and this fact led Mr. Disher to think that his peculiar walnut seedlings were natural hybrids between oak and walnut. Under the circumstances it is not strange that a layman should be led into error, but it is difficult to understand how any one of scientific training can persist in so evident a fallacy. To be convinced that somebody not only maintains this fallacy but is actively engaged in misrepresenting the true nature of these trees, it is only necessary to read the following communication.[3]

————, Cal.
August, 1914.

"President State Normal School,
————, Cal.

"Dear Sir:

"I am now able to offer you what I believe to be the rarest and the most remarkable tree in the world. It is a hybrid between a live oak and the California walnut. It bears oak-like leaves and walnuts. It has been named *Juglans quercifolia*. It is the dominant of Mendel from which I should be able to rear a recessive tree bearing walnut-like leaves and acorns.

"I have sold many of these trees to Kew, Edinburgh, Berlin, New York and elsewhere. I can supply these dominant trees at $10.00 each and probably recessives next year. A discount on dozen lots.

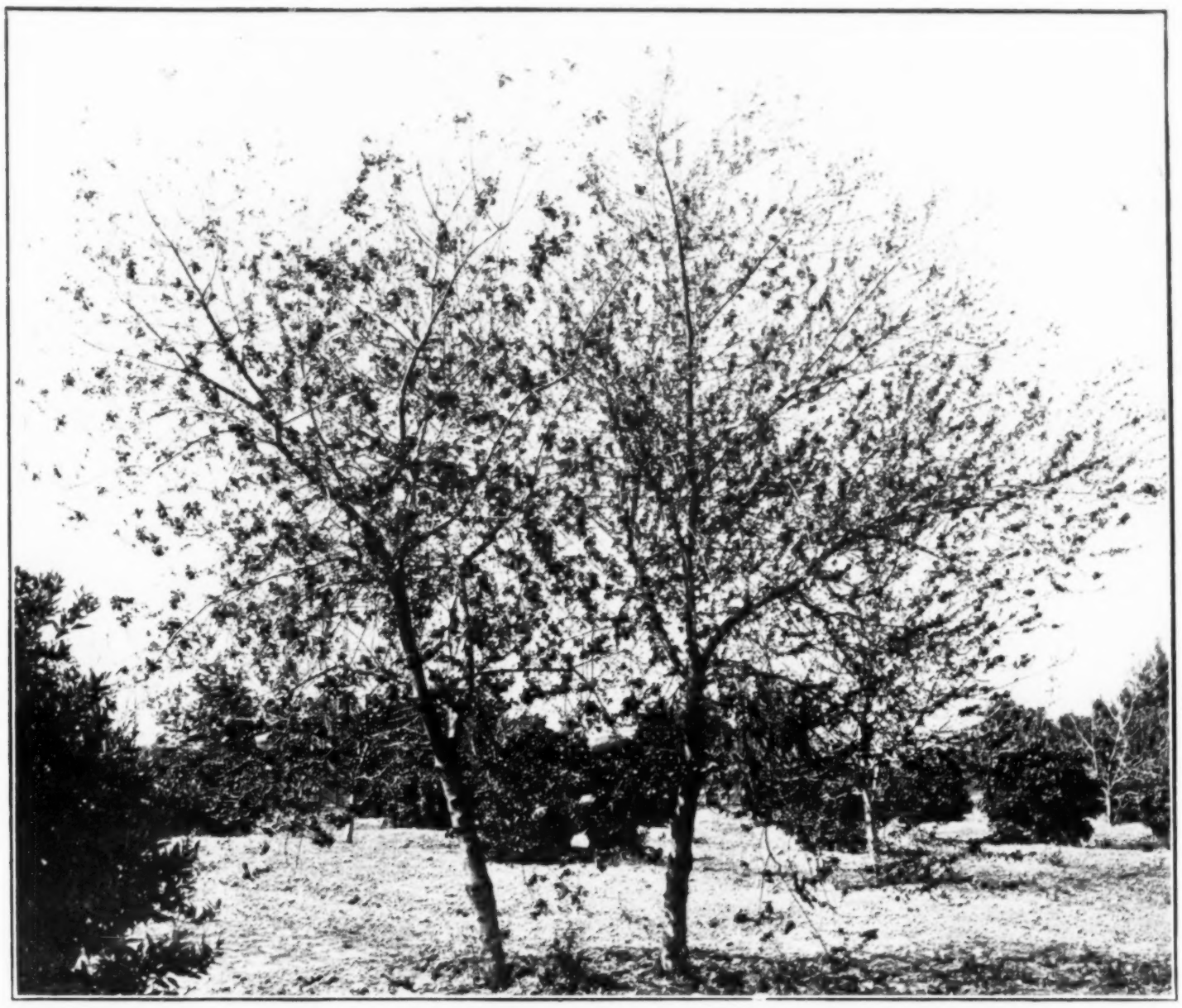
"Growing a dominant and recessive side by side you would have the most remarkable demonstration of Mendel's law to be found on earth. An oak bearing walnuts and a walnut bearing acorns!

"I am expecting to locate this tree at the

[1]Babcock, E. B. Studies in Juglans I. Study of a New Form of *Juglans californica* Wats. Univ. of Cal. Pub. Agric. Sciences, vol. 2, No. 1, 1913.

[2]Pierce, N. B. A New Walnut. Science n. s. vol. 37, No. 955, p. 613, 1913.

[3]This letter was sent to the writer by a member of the faculty of a state normal school with a request for an expression of opinion as to its veracity.



ORIGINAL SPECIMENS OF THE NEW WALNUT

Two of the original trees of the California mutant walnut which has been named *Juglans californica* var. *quercina*. The left-hand tree bears both staminate and pistillate flowers and produces a crop of nuts each year, which when planted produce trees resembling the parent. The right hand tree has only staminate flowers or, occasionally, abortive pistillate flowers, and hence produces no nuts. (Fig. 16.)

Normal School at ——— and therefore make you this offer. I may place some at———— also.

Sincerely yours,

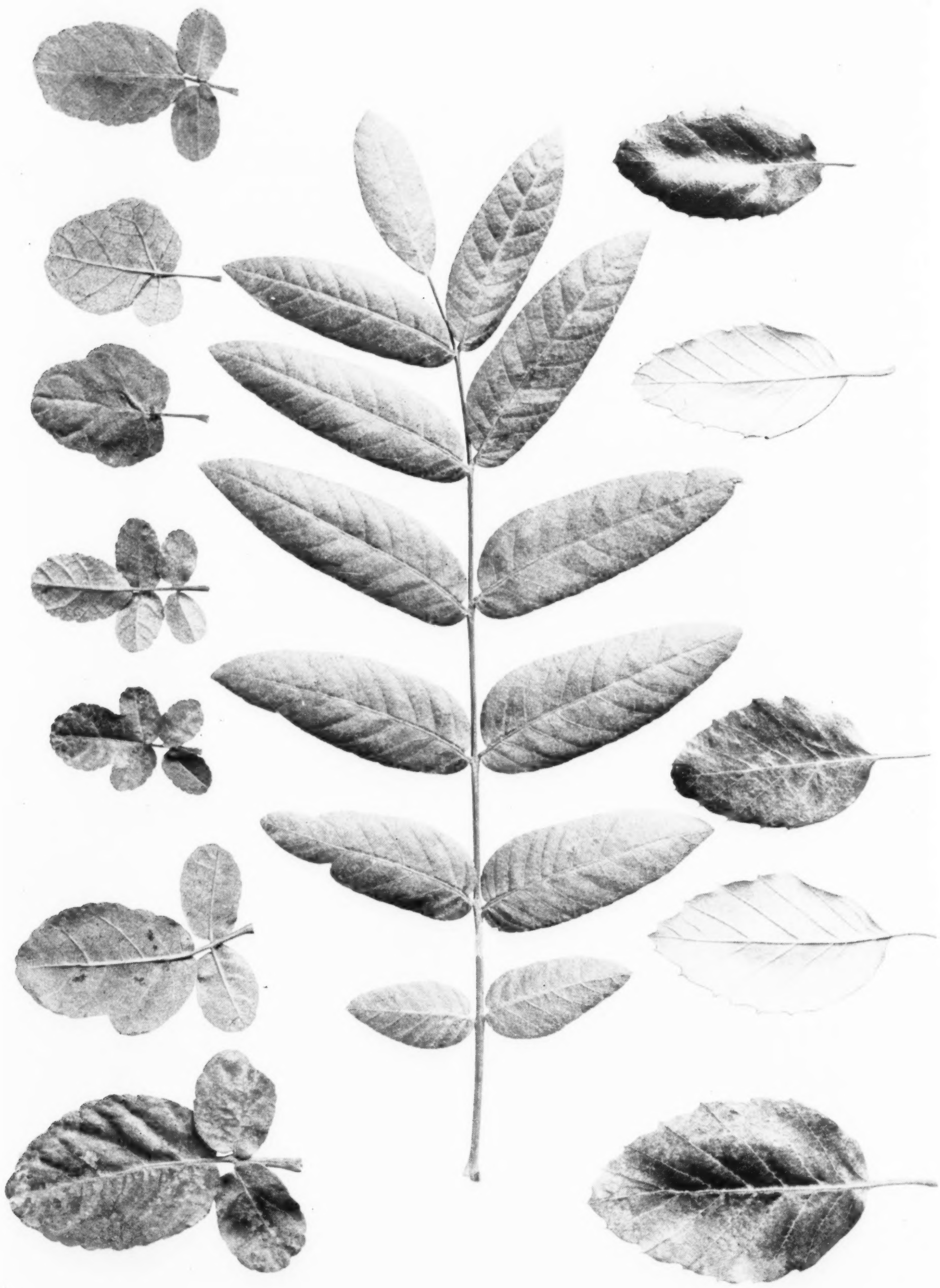
———————————

(P. S.) "There is no more beautiful tree for school grounds to be found on earth!"

I do not assert that this misrepresentation is made wilfully or even consciously. The purpose of this article is merely to expose the fallacy and inform those who are interested in this new form regarding its true nature. That it is not a hybrid but rather a mutation is proved by two supplementary lines of evidence, the result of my investigations during the past seven years.

In 1908, 1910 and 1911 I made a large number of cross-pollination experiments under bag on native black walnut trees with pollen from the live oak and two other native oaks with the result that from live oak pollinations alone I have 70 seedlings, 48 of which are six years old and, of these, 30 bore their first crop of nuts in 1913. The reciprocal cross was attempted but no seeds matured. Briefly, but accurately, I can state that no trace of oak nor of *quercina* characters can be found in any of the first generation seedlings from oak pollinations. Moreover, over 2,000 nuts were secured from 30 of the F_1 trees in 1913 and the seedlings were raised this year. Again there was absolute failure to detect any oak or *quercina* characters. Both the F_1 and F_2 seedlings appear like the California Black Walnut. Although this is negative evidence, it indicates strongly that the original *quercina* trees did not originate through natural hybridization between walnut and oak.

In 1911, through the generous cooperation of William Tyler, of Garden Grove, California, I ascertained that the new form of walnut was produced by at least one individual in a row of 20 or 30



WHY THE NEW FORM IS NOT A HYBRID

Although the general appearance of the mutant is somewhat like that of the California live oak, its leaves show little resemblance, when studied in detail. In the center is a typical leaf of the Southern California black walnut (*Juglans californica*), the parent of the mutant; at the left is a series of leaves of the mutant, which has been given the variety name of *quercina;* at the right are typical leaves of the Coast Live Oak, *Quercus agrifolia*, which has been claimed as one of the parents of *quercina*. It will be noted at once, however, that the leaves of the mutant are compound, except in one case where there is a tendency toward a simple form. The two end leaves are the most characteristic of *quercina*, the other types being comparatively rare. (Fig. 17.)

California Black Walnut trees from which Mr. Tyler obtained nuts for his nursery. In 1912 I had the crop from each of 21 of those trees gathered separately and thus selected the particular tree which produces *quercina* seedlings. This tree is known as No. 16. In 1913 I had about 350 clusters of nuts on this tree gathered separately and tested and found that 42 clusters produced the new form, but, strange to say, there was only one *quercina* seedling among those from each cluster, the others being typical black walnuts. A fuller report on this work together with critical discussion appears elsewhere.[4]

NO MENDELISM FOUND.

No oaks, either native or exotic, are known to occur in the region of Garden Grove—certainly none in the immediate vicinity of tree No. 16. This eliminates the possibility of origin of the *quercina* progeny of tree No. 16 through hybridization with oak. The limitation of the production of *quercina* seedlings to only one of the 21 black walnut trees tested, indicates that the mutation does not occur in the staminate flowers of No. 16 or its neighbors but rather in the pistillate flowers of No. 16 itself. And, further, the fact, which has been amply demonstrated, that the new form does not breed true but usually produces some typical *californica* seedlings among its progeny, shows conclusively that the mutations occur in the pistillate flowers *before* fertilization, so that each *quercina* seedling produced by a black walnut tree is a hybrid in the sense that it combines the characteristics of the mutant and the parent and so reproduces both types. The proportion of *californica* and *quercina* seedlings found in the progeny of fruiting specimens of the new form is quite different for different specimens. I have tested the seeds from three different *quercina* trees and can state positively that I have never found any oaks among the progeny nor any Mendelian ratios between the numbers of *californica* and *quercina* seedlings produced. These facts considered together with the complete absence of specific oak characters in the new form should effectually dispel the notion that hybridization with oak has had anything to do with the origin of the new form.

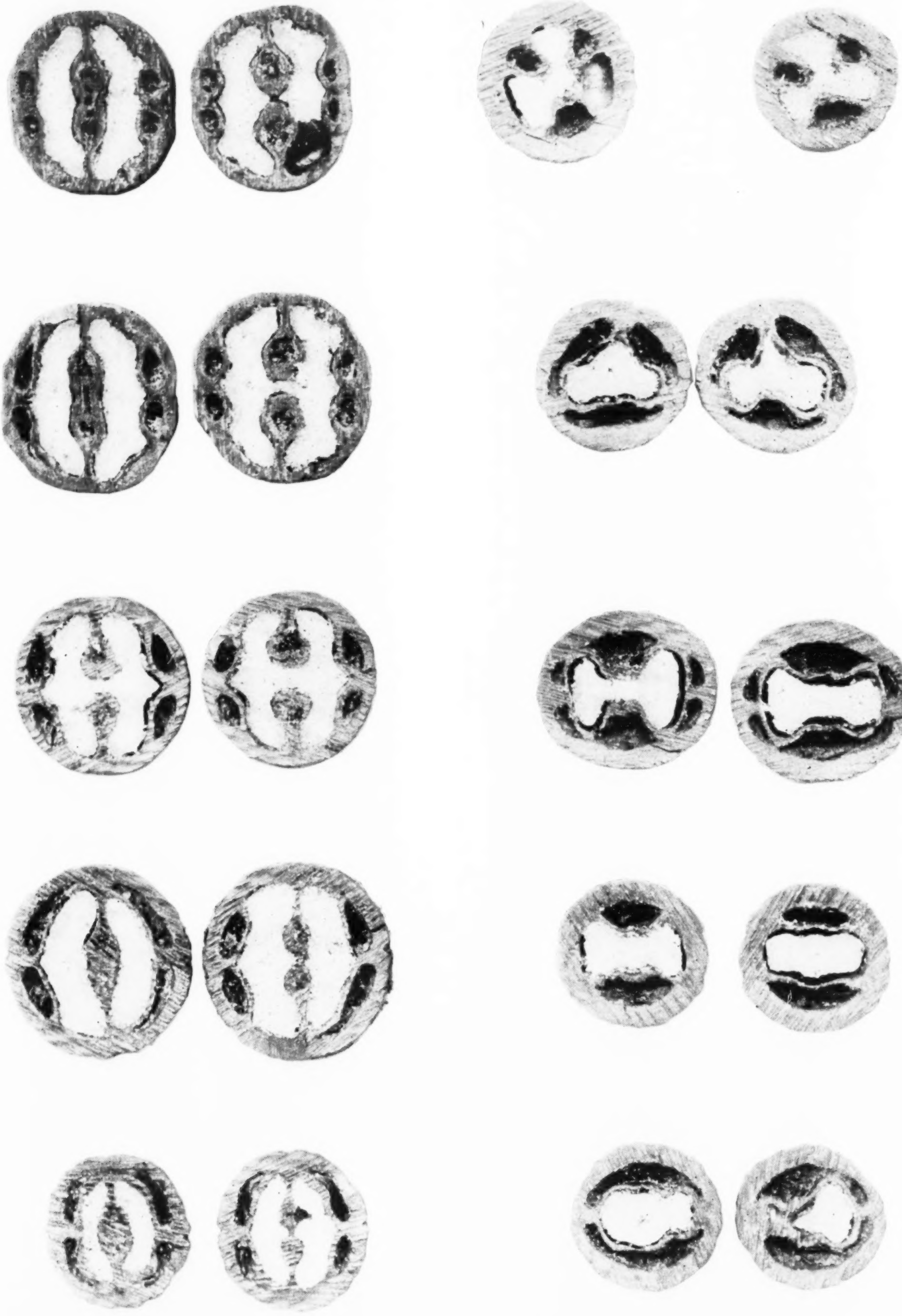
The original source of the new variety was the tree discovered by Disher in Santa Ana canyon, the parent of the original *quercina* trees shown in fig. 19. This tree was destroyed before the writer had seen its progeny. The next source to be discovered was a single tree in Santa Monica canyon near Los Angeles. Among a lot of nuts gathered in 1909 from wild walnut trees growing in that region, there was one nut that produced a *quercina* seedling. The third tree found to produce the new form is No. 16 in Garden Grove, California. The row of trees, of which it is one, was planted perhaps thirty years ago and I have not learned the location of their parents but all the individuals in the row are southern California Black Walnuts.

The fourth source of the new variety has just been discovered. It is of unusual importance for reasons of

NUTS OF PARENT AND MUTANT

At the left, three nuts of the Southern California black walnut; on the right three nuts of the variety *quercina* which suddenly appeared as a mutant from it. There is no real distinction between the two nuts, and not the slightest trace, in those on the right, of any influence of an oak, which is alleged by some horticulturists to have been one of the parents of the new form. (Fig. 18.)

[4]Babcock, E. B. Studies in Juglans II. Further Notes and Observations on a New Form of *Juglans californica* Wats. Univ. of Cal. Pub. Agric. Sciences, vol. 2, No. 2, 1914.



THE NUTS IN CROSS SECTION

At the left, typical nuts of the Southern California black walnut, at the right, typical nuts of the new variety *quercina*. Although this has been called a walnut-oak hybrid, there is nothing in the nuts, leaves, flowers or any other part of the plant to indicate that an oak entered its parentage, and as it has been produced several times under controlled conditions, from walnuts which were known not to be cross-pollinated, the story of the walnut-oak hybrid must be set down as a myth. (Fig. 19.)

interest to biologists. The three *quercina*-producing trees above mentioned are all southern California Black Walnuts and would be classified botanically as *Juglans californica*. The newly discovered source of *quercina* is the northern California Black Walnut, which has been named *Juglans californica* var. *hindsii* Jepson.[5] It is a form so different from the southern type of tree that it might easily be mistaken for a distinct species. The circumstances involved in this new appearance of *quercina* are too complicated to be related in full here. Let it suffice to say that without doubt *quercina* has sprung from *hindsii* as well as from *californica*. Since *quercina* comes from *californica* by mutation it is practically certain that *hindsii* produces the new variety by the same process. Although it does not follow of necessity, yet these facts would seem to indicate that *hindsii* also originated from *californica* by mutation. A full statement with illustrations concerning this latest development in the history of the oak-like walnut will be made as soon as it is feasible to do so.

It is worthy of note that this is a mutation in which there has been a change in all gross characters—size, shape, color and texture of leaves, size, form and number of parts of flowers, color of bark, habit of growth, etc. Such a transformation has been called aggregate mutation and cases have been reported in cotton, tomato, tobacco and evening primrose. The walnuts and their relatives are recognized by botanists and paleontologists as among the oldest of the angiosperms. Many species of walnuts existed in the various periods of geological history back to the Cretaceous. The known occurrence of one such aggregate mutation as produces *quercina* suggests that some if not all the species of walnuts existing or extinct may have originated in a similar manner.

That this new walnut is not a natural hybrid between oak and walnut, is indicated by the negative results of my experiments in artificial hybridization and proved by the demonstration of its origin through mutation, which has occurred not once but many times in at least four different trees of the California Black Walnut.

[5] Bul. S. Cal. Acad. Sci. vol. 7, p. 23, 1908.

Prepotence in Plant Breeding

The work of breeding new flowers, fruits and vegetables from natural or artificial crosses, has been, and I believe can still be, carried out excellently with a minimum of Mendelian theory. The most important idea, I think, is that of *prepotence*, or transmitting power, or strength of heredity, as it is sometimes called. This rather loose term, so far as I have seen, has been used to embrace at least the following different Mendelian cases:

(1) The dominance of a character in a first-generation hybrid. (The dominant parent is prepotent for the character.)

(2) The presence in the prepotent parent of a number of separate dominant characters, or of a number of characters inherited as a dominant unit. (An important case of prepotence.)

(3) The excess of dominants from the cross of a positive homozygote with a recessive, over those from the cross of a heterozygote with the recessive. (The pure-bred is more prepotent than the mongrel.)

(4) The presence of the dominant character in *all* the progeny of the back cross of a hybrid with its dominant (prepotent) parent, whereas only a fraction show the recessive character when the hybrid is crossed with the recessive parent.

(5) In cases of imperfect dominance, the difference in *appearance*, as well as in transmitting power, between the homozygous dominant and the heterozygote. (Recognition of prepotence by external characters.)

(6) The large excess of dominants in the progeny of selfed hybrid plants. (Influence of the prepotent grandparent.)

(7) The constancy of a selfed homozygous dominant, compared with a hybrid. (The former is prepotent.)

(8) The constancy of a selfed recessive compared with a hybrid. (The pure-bred has greater transmitting power.)

If, then, the breeder of improved plants uses pedigreed lines (centgener plots, or ear-row tests) instead of mixed cultures, and selects in each generation the plants which are most prepotent *for the particular characters* he needs, he can, I think, usually leave Mendelian formulae to those who are working to discover new facts.

John Belling,
Florida Agricultural Experiment Station.

MATERIAL FOR PLANT BREEDERS

MODERN plant breeding proceeds on two principal lines: first, by confining itself altogether to present commercial varieties and trying to improve them, usually by some form of selection; second, by the use of new forms, which may be either developed on their own merits, or combined with existing commercial strains through hybridization. The first method has preponderated during the last half century, but breeders at present show a tendency to adopt the second method in larger numbers every year. In the United States they probably find their greatest aid to this end in the Office of Foreign Seed and Plant Introduction, of the U. S. Department of Agriculture at Washington.

This office has just issued its Fourth Annual List of New Plant Introductions, in which about 300 species or varieties of plants and seeds which it has recently secured are succinctly described in an accurate and understandable way. This material is available now or will be later available to any bona fide breeder who has proper facilities for making good use of it.

Much of it, as the introduction to the list points out, is as yet little known even botanically, and quite unknown horticulturally, as far as the United States are concerned. The plants described have been imported from all parts of the world because it is hoped that, indirectly or directly, they may be of use to Americans. "They are introduced primarily for use by the Federal and State Experiment Stations of the country, but are available to such private experimenters as have the necessary facilities and are desirous of testing them, notwithstanding the fact that they are quite untried commercially.

"Since these plants must ultimately be grown by private individuals before their commercial success is assured, it may be well to point out that those private experimenters who test these problematical new plants are assisting in a very practical way in the plant introduction work of the country even though they are not paid for their work.

"It is often around the successful cultivation of a new introduction by some private individual that a new plant industry begins."

SOME OF THE FEATURES.

While the list is made up largely of plants hardly known by name to the American horticulturist, there are also many species of common economic plants, in which every breeder will take an interest, now that the great potential value of wild relatives of our cultivated plants is being widely realized. There are, for example, 10 species of Amygdalus inventoried, part of which are to be classed among peaches and part among almonds. Many of them are adapted to extreme climatic conditions, and may prove valuable in themselves, as well as for breeding. Similarly there are three promising species of Citrus, besides the rare *Eremocitrus glauca* or Australian Desert Lime, probably the hardiest of all the citrous fruits. The persimmon genus, Diospyros, which has lately been attracting a good deal of attention from American breeders, is represented in the list by three species, while eight species of Malus will attract the numerous apple growers who are seeking new "creations." There are four promising species of Olea, the olive genus, 10 of poplar, some of which can hardly fail to be of value in the treeless regions of the Northwest, 12 of Prunus, including several hybrids, and 11 of willow. To cite even a fair selection of the isolated novelties would require too much space, but mention may be made of an edible chrysanthemum from China, the leaves of which are said to be a good substitute

for kale and spinach; the Indian coral tree (*Erythrina arborescens*), whose 12-inch spikes of brilliant scarlet blossoms remind one of the peerless Royal Poinciana, but which has the advantage of greater hardiness; the romantic Hawaiian Cotton Tree (*Kokia rockii*) which apparently was saved almost by chance from absolute extinction a few years ago; the handsome *Persea borbonia* of the southern United States, which may be of value to breeders of the avocado; an elm (*Ulmus densa*) from Turkestan, which should successfully withstand the alkaline soil and arid climate of the Southwest; and the large collection of melons from all parts of the world, any one of which may prove to be a prize in some locality adapted to it.

Any person interested in plant breeding, and willing and able to make use of novelties, should communicate with the Office of Foreign Seed and Plant Introduction, stating the amount of land at his disposal, whether owned or leased, whether plants are desired for greenhouse or indoor culture, and his experience in caring for and experimenting with plants. He will then be placed on the mailing list of the office, and be furnished with any of its material that he is able to utilize profitably.

Wheat X Rye Hybrids

Hybrids between wheat and rye are described by Fr. Jesenko in the Ztschft. f. ind. Abstammungs und Vererbungs-Lehre (X, 311-326). They are possible only when wheat is used as the seed-bearer or mother plant. From 6,100 pollinations the experimenter secured 35 heads of grain, which proved to be self-sterile. There appears to be blending in some characters and prevalence or dominance in others. These hybrids when crossed back on rye produced with one exception, nothing, when crossed back on wheat set grain in about 3% of the cases. The product of this cross was diverse; in general it much resembled wheat and the plants which seemed closest to wheat in appearance were in general the most fruitful. The one grain secured in the back cross on rye produced a plant strongly resembling rye

A Department of Eugenics

The *Red Back Texas Medical Journal*, published at Austin, now includes a "Department of Eugenics," edited by Dr. Malone Duggan and Dr. Theodore Y. Hull, both of San Antonio. It is devoted principally to sex hygiene and other sanitary measures.

Race Regeneration and Law

If even the problem of the extirpation of the feeble-minded classes can be approached and largely settled on a voluntary basis, without any risky experiments in legislation, much more is this the case with the higher breeding of the race, as it may be exercised by the fully sane and responsible classes. Here is emphatically the field of the moralist, who need not feel called on to forfeit his claim to being called a moralist by clamoring for the brute force of law. Even if scientific opinion and general public opinion were ready for marriage legislation in the interests of the regeneration of the race it would still be a problem how far such legislation is likely to be in accordance with sound morals. For legislation can only demand actions that are both generalised and externalised, and the demands of the regeneration of the race must be both particularised and internalised, or they are meaningless and even void. The law may, for instance, enact prohibitions against certain kinds of people marrying, but it cannot so prevent procreation, and the mere prohibition to marry is both unjust and unnecessary in so far as it prevents the unions of people who may be fully aware of their racial disabilities and consequent responsibilities and ready to act accordingly. Thus it is that morals is called upon to retain jealously within its own sphere these aspects of racial regeneration, and to resent the encroachments of law.—Havelock Ellis: The Problem of Race-Regeneration (1911).

NEW PUBLICATIONS

SEX: ITS ORIGIN AND DETERMINATION, by Thomas E. Reed, M. D.; 312 pages, $2.50. Rebman Company, New York, 1914.

In this well-advertised book the author, a physician, undertakes to supply some new conceptions concerning "The Nature of Life, Reproduction and Sex, the latent bisexuality of all animal life and the primitive hermaphroditism of the germ plasm; the nature and origin of twins, particularly of conjoined twins; the primitive alternating and metabolic nature of sex; the manifestations of lunar rhythms in labor, in infectious disease, their influence on births, deaths, surgical operations, menstruation, gestation and the determination of sex." Obviously a big job.

The thing that is new in the book is a theory that there is a cycle in animal life, of shorter duration than the well-known monthly cycle, manifested in the germ cells and the developed organism, and having an effect upon the determination of sex as well as on the progress of labor and other vital processes. The lunar day divided into two twelve hour periods, and these in turn divided into two six hour periods—a "positive" and a "negative"—supplies this cycle. A positive period—based on the position of the moon—is one during which the moon passes from the eastern horizon to the zenith, or from the western horizon to nadir. A negative period is one during which the moon passes from zenith to the western horizon, or from nadir to the eastern horizon. The theory further postulates that the ovum is alternatingly male and female, and that the sex that arises from it depends upon the stage the ovum happens to be in when fertilized. If fertilized during a positive period a male results; fertilization during a negative period produces a female. This the author claims practically to have established for the human subject.

The wonder is, however, that with so wide and extended a practice there were so few cases—about 20—to cite as evidence and that these were not all cited. And still greater the wonder that with all the energy spent in digesting literature and in deductive reasoning, the simple expedient of recourse to observation and experiment on animals—even domestic animals—was not resorted to. Here the whole theory of alternating hermaphroditism of the ovum and the author's general theory of sex determination would have been quickly disproved. Indeed, merely to have glanced in this direction—without further experimentation—would, as every biologist knows, have been quite conclusive. Whatever the inherent virtues of a tide-table, there is no reason to suspect that within it there lurks the sentence of sex.

OSCAR RIDDLE.

HEREDITY AND SEX, by Thomas Hunt Morgan, Ph.D., New York, Columbia University Press, 1913. Pp. xi + 282, $1.75 net.

This book of Dr. Morgan, professor of experimental zoology at Columbia University, is the standard authority on the relations between heredity and cytological research. It discusses in detail the recent microscopical studies of the cell and its chromosomes, and the Mendelian theories, as interpreting heredity, and particularly, of course, the inheritance of sex. The author considers as exploded the idea that external conditions determine sex, believing that it is determined through the internal mechanism of the cell itself, as a result of the laws of chance. He explains some of the contradictory results published by other experimenters by saying, "the environment may slightly disturb the regular working out of the two possible combinations that give sex male or female. Such disturbances may affect the sex ratio but have nothing to do with sex determination."